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"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
C. B. MORSE, - - - Managing Editor
J. E. QUINTERO, - - - - - Treasurer

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 11 Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. XI. MARCH, 1906. NO. 1

A New Volume.

With this issue COMPRESSED AIR begins its eleventh year. We have in prospect for the near future several changes in the appearance and arrangement of the magazine which will, we hope, serve to make it more attractive to our readers.

COMPRESSED AIR differs essentially from most of the popular or technical magazines in that it deals exclusively with one subject and stands alone in that field. From the time of its conception it has aimed to sum up the current information on the subject of compressed air and to assist in the discussion and publication of such ideas and suggestions as may deal with its development.

While compressed air was by no means unknown a decade ago, this period has shown a remarkable change in the general attitude of both the general and engineering public toward this method of power transmission. In wide and distinctive fields compressed air has found its place. There are still many opportunities before it which time will develop.

COMPRESSED AIR is not the organ of an experimental science but deals with practical subjects. The new inventions and the experiments all have their place in our columns but it has been our consistent policy to deal at length with the practical uses of this power and to include much that can be read with interest and profit by the man who is called upon to use air under pressure in the course of his daily work.

Descriptive technical articles are published in these columns at frequent intervals. One of special importance is given space in this issue. It deals with the different formulae relating to the compression of air and should be preserved by every engineer who has to deal with air under pressure.

Ten years ago it was an open question whether there was a sufficiently large reading public among those interested in compressed air to support a publication devoted exclusively to that subject. COMPRESSED AIR was started and the course of events has conclusively proven that it has its place. The growth has been a steady and a healthy one. The same policy in the conducting of this magazine which has been successful in the past will be followed in the year to come. Effort will be made to increase its usefulness in its particular field. In this we ask the co-operation of our readers.

Suggestions as to ways in which the magazine can be improved, will be cordially welcome. Its columns are always open to contributions on any feature of the general topic. If you have problems in the use of compressed air regarding which you desire assistance, write to us. We will gladly help you or put you in touch with some one who can. Such inquiries often prove of general interest and start a discussion which will be of material assistance to many.

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We thank our advertisers for their support during the last twelve months. COMPRESSED AIR does not claim a circulation equal to many of that of the general engineering publications. It has, however, this one advantage: Every copy goes to some one who is interested in compressed air. If you would reach the people who are looking for information on this subject, COMPRESSED AIR offers the only practical medium.

A Compressed Air Saw.

Readers of COMPRESSED AIR may remember a description of the Redfield compressed air saw which appeared in the February, 1904, issue. We have had a number of inquiries for that device since that article appeared, the latest coming from a man interested in a northern Minnesota timber proposition. He contemplates beginning work at an early date and wants to use the very latest improved appliances. Having heard of this saw in question, he wrote to us for information. The saw is built by the Ashland Iron Works of Ashland, Oregon, and was given its first practical trial in the woods by the McCloud River Lumber Company, of McCloud, California.

If any readers of COMPRESSED AIR have any further information regarding either this saw or any other operated by compressed air, we shall be pleased to give it space in the coming issues of this publication. There appears to be a distinct field for devices of this nature for use in the western logging camps.

Sea Level or Lock Canal.

Without doubt, the greatest engineering project of the present century is the task which the United States Government has assumed in the building of the Panama Canal. Included in this is the removal of over 100,000,000 cubic yards of rock. In this gigantic undertaking compressed air is bound to come to the fore as an absolute essential for the rapid and economical completion of this part of the work. For that reason readers of COMPRESSED AIR will find it of interest to keep in touch with the progress being made.

The last step has been the forwarding by President Roosevelt to Congress of the report of the Board of Consulting Engineers. This report consists of two parts, one being the plan of eight members of the Board and in favor of the sea-level canal; the other being the report of five members of the Board recommending the canal with a summit of eighty-five feet above the sea, to be reached by locks. The report was accompanied by a letter to Secretary of War Taft from Chief Engineer Stevens and the members of the Isthmian Canal Commission, with the exception of Admiral M. T. Endicott. The members of the Commission and Mr. Stevens endorsed the minority report, which favors the eighty-five foot lock canal. Admiral Endicott advocated the sea-level structure, as outlined in the majority report. President Roosevelt's letter of transmissal places him among those who favor the lock canal.

A careful perusal of the report makes it clear that the majority has based its recommendation on the belief that the greater efficiency and ultimate value of the sea-level canal make it more than worth the extra cost and the slightly increased time of construction it requires. Its international character makes the conditions under which it will be operated so radically different from those of similar enterprises on a smaller scale that it is hardly fair to judge one by the other. While the completion of the canal at as early a date as possible is a thing much to be desired, the question of a few years should not be allowed to interfere and impair the efficiency of an undertaking of this nature which is destined to serve the people of this and other countries for many generations to come.

Every citizen of the United States, particularly those who are interested in the engineering projects of the land, should not fail to become conversant with the plans of construction now under consideration. Through the courtesy of the *Engineering Record,* COMPRESSED AIR will give in a coming issue an illustrated resume of the essential features of the sea-level canal as advocated by the majority of the Board of Consulting Engineers. An abstract of the plan for the lock canal as proposed by the minority will be given later.

Derivation of Formulae for Single and Stage Compression; also, Proof of Conditions Governing Best Proportioning and Highest Economy in Stage Compression.

BY EDWARD F. SCHAEFER, M. M. E.

In estimating various items in air compression, the usual and, of course, the natural and desirable way of proceeding is to employ formulae which have previously been worked out. This practice saves time, and eliminates, to a large extent, errors that would be apt to appear in long calculations.

Of all the equations used in solving problems, there is hardly one more important or more frequently employed than that which expresses the *work done* in compressing air or gas. It is the author's purpose to show how this useful formula for horse-power is developed.

Adiabatic compression occurs when a decrease in volume is attended by an increase in both pressure and temperature, according to the law:

$$p_1 v_1^{1.41} = p_2 v_2^{1.41} = \text{Constant}$$

In this equation p_1 and v_1 are the pressure in pounds per square foot and the volume in cubic feet, respectively, at a certain point during compression or expansion; p_2 and v_2 are the pressure and volume at another point.

Although in practice pure adiabatic compression is impossible—nor is it desired—the actual compression approximates the adiabatic closely. We assume, therefore, that the two are identical; in any case any slight error is on the safe side.

In stage compression the same assumption holds, but to reduce the work done on the air and increase the efficiency of the compressor the air is cooled between stages by means of an intercooler.

Fig. 1 shows an ideal indicator card, EG represents the vacuum and CH the atmospheric lines. Beginning at H, we find that air is sucked into the cylinder to C and at atmospheric pressure p_1; at C compression begins—this compression is adiabatic and continues to A, a point where the exhaust valves open; along AF and at the pressure p_2 air is transferred from the compressor cylinder to a receiver or intercooler, as the case may be. At F the admission valves open, the pressure in the cylinder falls to p_1 and a fresh charge of air is taken into the cylinder. Thus the cycle is represented by the figure HCAF. This area is equivalent to the work done in compressing and transferring a cylinderful of air.

Work done = ACEGF — HCEG
or work done = ADEC + AFGD — HCEG
But AFGD = $p_2 v_2$
and HCEG = $p_1 v_1$
∴ work done = ADEC + $p_2 v_2 - p_1 v_1$ ....(1)

It remains now to show what the value of the area ADEC is in terms of p_1, v_1, p_2 and v_2.

From Calculus we know that:

$$\text{ADEC} = \int p \, . \, dv \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

in which p represents any pressure from C to A, and dv any increment in volume along ED.

The law governing adiabatic compression is:

$$p v^n = p_1 v_1^n \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

in which the index n is equal to 1.41.

Re-writing (3) we get:

$$p = \frac{{}_1 v_1^n}{v^n} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

In compressing air from C to A, the volume changes from v_1 to v_2, and therefore:

$$ADEC = \int_{v_2}^{v_1} \frac{p_1 v_1^n}{v^n}\, dv \ldots\ldots\ldots\ldots\ldots (5)$$

$$= p_1 v_1^n \int_{v_2}^{v_1} \frac{dv}{v^n}$$

$$= p_1 v_1^n \int_{v_2}^{v_1} v^{-n}\, dv$$

$$= p_1 v_1^n \left(\frac{v^{-n+1}}{-n+1}\right)_{v_2}^{v_1}$$

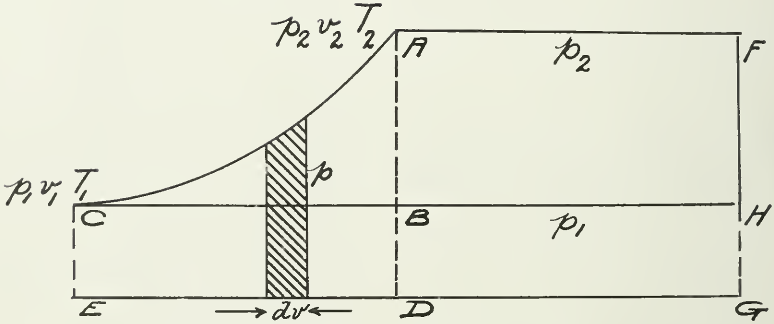

Fig. 1

$$= p_1 v^n (v_1^{-n+1} - v_2^{-n+1}) \div (-n+1)$$

$$= \frac{p_1 v_1^n}{n+1} (v_2^{1-n} - v_1^{1-n})$$

Multiply by $(v_1^{1-n}) \div (v_1^{1-n})$

$$ADEC = \frac{p_1 v_1}{n-1} \left(\frac{v_2^{1-n}}{v_1^{1-n}} - 1\right)$$

$$= \frac{p_1 v_1}{n-1} \left(\frac{v_1^{n-1}}{v_2^{n-1}} - 1\right)$$

Substituting this result in equation (1) we have:

$$\text{Work done} = \frac{p_1 v_1}{n-1} \left(\frac{v_1^{n-1}}{v_2^{n-1}} - 1\right) + p_2 v_2 - p_1 v_1$$

$$= \frac{p_1 v_1 v_1^{n-1} - p_1 v_1 v_2^{n-1}}{(n-1) v_2^{n-1}} + p_2 v_2 - p_1 v_1$$

Reducing this expression to a common denominator, simplifying the numerator, reducing and remembering that $p_1 v_1 = p_2 v_2$, we get:

$$\text{Work done} = \frac{n}{n-1} (p_2 v_2 - p_1 v_1)$$

Substituting for n its value 1.41, the following is deduced:

$$\text{Work done} = 3.45\, (p_2 v_2 - p_1 v_1)$$

$$\text{But } p_2 = \frac{p_1 v_1^n}{v_2^n}$$

$$\text{Work done} = 3.45 \left(\frac{p_1 v_1^n v_2}{v_2^n} - p_1 v_1\right)$$

$$= 3.45\, p_1 v_1 \left(\frac{v_1^{n-1}}{v_2^{n-1}} - 1\right)$$

From equation (3) we have:

$$\left(\frac{v_1}{v_2}\right)^n = \frac{p_2}{p_1}$$

$$\text{Or } \left(\frac{v_1}{v_2}\right)^{n-1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$$

Substituting the result just found in the above equation, we have:

$$\text{Work done} = 3.45\, p_1 v_1 \left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]$$

And this expression, when reduced by using the value of n, becomes:

$$\text{Work done} = 3.45\, p_1 v_1 \left[\left(\frac{p_2}{p_1}\right)^{0.29} - 1\right] \ldots (6)$$

This equation expresses the amount of work done in foot pounds to compress and deliver one cubic foot of free air, adiabatically, from a pressure p_1 to another pressure p_2.

By dividing by v_1 the expression will represent the mean effective pressure (M. E. P.) per stroke, or,

$$\text{M. E. P.} = 3\,45\, p_1 \left[\left(\frac{p_2}{p_1} \right)^{0.29} - 1 \right] \ldots\ldots (7)$$

and therefore

$$\text{H. P.} = \frac{144}{33000} . \quad \text{M. E. P.}$$
$$= .00436 \text{ M. E. P.} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

in which the pressures are reduced to pounds per square inch.

Example I.

Required the horse-power necessary to compress one cubic foot of free air adiabatically to 90 pounds per square inch gauge pressure in a single-stage.

$$\text{M. E. P.} = 3.45\, p_1 \left[\left(\frac{p_2}{p_1} \right)^{0.29} - 1 \right] \ldots\ldots (7)$$

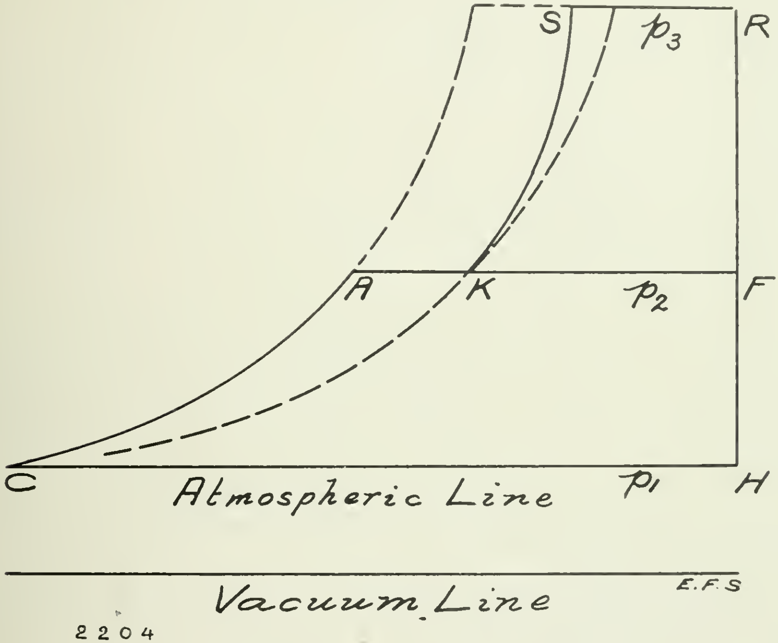

Fig. 2

$p_1 = 14.75$ pounds per square inch
$p_2 = 14.75 + 90 = 104.75$ pounds per square inch
M. E. P. $= 3.45 \times 14.75\ (1.76 - 1) = 38.68$
or H. P. $= .00436 \times$ M. E. P. $= 0.169$ per cubic foot of free air in *single stage* compression.

It was proved by F. A. Halsey that in proportioning compound compressor cylinders, best results are obtained by dividing the work equally between the cylinders, or by proportioning them so that maximum saving in power is effected (*American Machinist*, March 31, 1898).

Letting

$$\frac{p_3}{p_1} = \text{R}$$

$$\frac{p_2}{p_1} = r_1$$

$$\frac{p_3}{p_2} = r_2$$

Mr. Halsey found that for best proportioning

$$r_1 = r_2 = \sqrt{R} \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

$$\text{Now} \quad \frac{p_2}{p_1} \times \frac{p_3}{p_2} = r_1\, r_2 = R$$

$$\therefore r_2 = \frac{R}{r_1}$$

If $W_{l.p.}$ = work in low pressure cylinder
$W_{h,p.}$ = work in high pressure cylinder

then from (6)

$$W_{l.p.} = 3.45\, p_1\, v_1 (r_1^{0.29} - 1) \ldots\ldots\ldots (10)$$

$$W_{h.p.} = 3.45\, p_2\, v_2 (r_2^{0.29} - 1) \ldots\ldots\ldots (11)$$

The total work done by the compressor is equal to the sum of the work done in the low pressure and that done in the high pressure cylinder, or,

$$(W_{l.p.} + W_{h\ p.})$$

$$W_{l.p.} + W_{h.p.} = 3.45\, p_1\, v_1 (r_1^{0.29} - 1)$$
$$+ 3.45\, p_2\, v_2 (r_2^{0.29} - 1) \ldots\ldots\ldots\ldots\ldots (12$$
$$p_1\, v_1 = p_2\, v_2$$
$$= 3.45\, p_1\, v_1 (r_1^{0.29} - 1 + r_2^{0.29} - 1)$$
$$= 3.45\, p_1\, v_1 (R^{\frac{0.29}{2}} + R^{\frac{0.29}{2}} - 2)$$
$$= 3.45\, p_1\, v_1 (2\, R^{0.145} - 2)$$
$$= 6.90\, p_1\, v_1 (R^{0.145} - 1) \ldots\ldots\ldots\ldots\ldots (13)$$

The equation expresses the amount of work done in foot pounds to compress and deliver one cubic foot of free air, adiabatically, from a pressure p_1 to another pressure p_3 in *two* stages.

Dividing (13) by v_1 we get the M. E. P. reduced to the low pressure cylinder.

$$\text{M. E. P.} = 6.90\, p_1 (R^{0.145} - 1) \ldots\ldots\ldots (14)$$

$$\text{H. P.} = \frac{144}{33000}\ \text{M. E. P.} = .00436\ \text{M. E. P.} (15)$$

in which the pressures are expressed in pounds per square inch.

Example II.

Required the horse-power necessary to compress one cubic foot of free air adiabatically to 90 pounds per square inch gauge pressure in two-stage compression.

Fig. 2 shows the ideal combined cards from a compound compressor.

As stated above, after compressing the air adiabatically from C to A the heat due to the compression is removed by passing the air through an intercooler. The temperature falls to that of the free air and the volume decreases from A to K. K is the point where the isothermal line cuts the line representing the receiver pressure.

In equation (13) $R = \frac{p_3}{p_1}$

p_1 = 14.75 pounds per square inch.
p_3 = 14.75 + 90 = 104.75 pounds per square inch.

$$\text{M. E. P.} = 6.90 \times 14.75\, [(7.12)^{0.145} - 1]$$
$$= 6.90 \times 14.75\, [1.329 - 1] = 33.48$$

or H. P. = .00436 × M. E. P. = 0.145 per cubic foot of free air in *two-stage* compression.

In general, therefore, horse-power, whether *single-* or *two*-stage, is expressed by

$$\text{H. P.} = .00436\ \text{M. E. P.}$$

For single-stage compression:

$$\text{M. E. P.} = 3.45\, p_1 \left[\left(\frac{p_2}{p_1} \right)^{0.29} - 1 \right]$$

For two-stage compression:

$$\text{M. E. P.} = 6.90\, p_1 \left[\left(\frac{p_3}{p_1} \right)^{0.145} - 1 \right]$$

These three equations will be found adequate for general compressor operations and are, as here given, in the simplest possible forms.

At times, however, circumstances are such that triple or quadruple compression is necessary, and for such cases the formulae given below are to be employed.

For three-stage compression:

$$\text{M. E. P.} = 10.35\, p_1 \left[\left(\frac{p_3}{p_1} \right)^{0.097} - 1 \right]$$

For four-stage compression:

$$\text{M. E. P.} = 13.80\, p_1 \left[\left(\frac{p_3}{p_1} \right)^{0.0725} - 1 \right]$$

For five-stage compression:

$$\text{M. E. P.} = 17.25\, p_1 \left[\left(\frac{p_3}{p_1} \right)^{0.058} - 1 \right]$$

In general:

$$\text{M. E. P.} = 3.45\, N p_1 \left[\left(\frac{p_3}{p_1} \right)^{\frac{0.29}{N}} - 1 \right]$$

in which N represents the number of stages in which the compression is to be accomplished, p_1 the intake absolute pressure and p_3 the terminal absolute pressure.

Occasions frequently arise when it is of importance to be able to determine with dispatch the horse-powers needed to compress air, having given the terminal pressure.

In the formulae given the only quantity necessary is the terminal absolute pressure.

For single-stage compression:

$$\text{H. P.} = 0.10163\,(p^{0.29} - 2.183)$$

For two-stage compression:

$$\text{H. P.} = 0.30043\,(p^{0.145} - 1.477)$$

For three-stage compression:

$$\text{H. P.} = 0.51319\,(p^{0.097} - 1.297)$$

For four-stage compression:

$$\text{H. P.} = 0.72983\,(p^{0.0725} - 1.216)$$

H. P. = Horse-power per cubic foot of free air at *sea level.*

p = terminal gauge pressure in pounds per square inch ÷ 14.75.

In general:

$$\text{H. P.} = \frac{0.2218695N}{(14.75)^{\frac{0.29}{N}}}\left[p^{\frac{0.29}{N}} - (14.75)^{\frac{0.29}{N}}\right]$$

These expressions are applicable to *sea level* conditions only.

Horse-Power and Mean Effective Pressure Developed in Compressing One Cubic Foot of Free Air From Atmospheric Pressure to Various Gauge Pressures. Initial Temperature of Air in Each Cylinder 60° F. Jacket Cooling Not Considered.

Gauge Pressure	Atmospheres Compressed	Isothermal Compression		Adiabatic Compression								Percent. of Power Saved by Two-Stage over Single-Stage Compression
				Single-Stage				Two-Stage				
		M. E. P.	Horse-Power	M. E. P. Theoretical	M. E. P. 15% Friction Included	H. P. Theoretical	H. P. 15% Friction Included	M. E. P. Theoretical	M. E. P. 15% Friction Included	H. P. Theoretical	H. P. 15% Friction Included	
5	1.34	4 13	.018	4.46	5.12	.019	.022	......	......	....	....	....
10	1.68	7.57	.033	8.21	9.44	.036	.041	......	......	....	....	....
15	2.02	11.02	.048	11.46	13.17	.050	.057	......	......	....	....	....
20	2.36	12.62	.055	14.30	16.44	.062	.071	......	......	....	....	....
25	2.70	14.68	.064	16.94	19.47	.074	.085	......	......	....	....	....
30	3.04	16.30	.071	19.32	22.21	.084	.096	......	......	....	....	....
35	3.38	17.90	.078	21.50	24.72	.094	.108	......	......	....	....	....
40	3.72	19.28	.084	23 53	27.05	.103	.118	......	......	....	....	....
45	4.06	20.65	.090	25.40	29.21	.111	.127	......	......	....	....	....
50	4.40	21.80	.095	27.23	31.31	.119	.136	......	......	....	....	....
55	4.74	22.95	.100	28.90	33.23	.126	.145	......	......	....	....	....
60	5.08	23.90	.104	30 53	35.10	.133	.153	......	......	....	....	....
65	5.42	24.80	.108	32.10	36 91	.140	.161	......	......	....	....	....
70	5.76	25.70	.112	33.57	38.59	.146	.168	29.31	33.71	.128	.147	12.3
75	6.10	26.62	.116	35.00	40 25	.153	.175	30 43	34.99	.133	.153	13.1
80	6.44	27.52	.120	36.36	41.80	.159	.182	31.44	36.15	.137	.158	13.6
85	6.78	28.21	.123	37.63	43.27	.164	.189	32.46	37.22	.142	.163	13.7
90	7.12	28.93	.126	38.89	44.71	.169	.195	33 37	38.36	.145	.167	14.2
95	7.46	29.60	.129	40.11	46.12	.175	.201	34.28	39.41	.149	.172	14.8
100	7.80	30.30	.132	41.28	47.46	.180	.207	35.20	40.48	.153	.176	15.0
110	8.48	31.42	.137	43.56	50.09	.190	.218	36.82	42.34	.161	.185	15.2
120	9.16	32.60	.142	45.69	52.53	.199	.229	38.44	44.20	.168	.193	15.5
130	9.84	33 75	.147	47.72	54.87	.208	.239	39.86	45.83	.174	.200	16.3
140	10.52	34.67	.151	49.64	57.08	.216	.249	41.28	47.46	.180	.207	16.6
150	11.20	35.59	.155	51.47	59.18	.224	.258	42.60	48.99	.186	.214	16.9
160	11.88	36.30	.158	53.70	61.80	.234	.269	43 82	50.39	.191	.219	18.4
170	12.56	37.20	.162	55.60	64.00	.242	.278	44.93	51.66	.196	.225	19.1
180	13.24	38.10	.166	57.20	65.80	.249	.286	46 05	52.95	.201	.231	19.3
190	13 92	38.80	.169	58.80	67.70	.256	.294	47.16	54.22	.206	.236	19.5
200	14.60	39.50	.172	60.40	69.50	.263	.303	48.18	55.39	.210	.241	20.1
250	18.00	42.70	.186	67 00	77.10	.292	.336	52.84	60.76	.230	.264	21.2
300	21.40	45.30	.197	72.80	83.80	.317	.365	56.70	65.20	.247	.283	22.1
350	24.80	47 30	.206	78.50	90.40	.342	.394	60.15	69.16	.262	.301	23.4
400	27.20	49.20	.214	83.50	96.20	.364	.418	63.19	72 65	.276	.317	24.2
450	31 70	51.20	.223	87.50	100.80	.381	.438	65 93	75 81	.287	.329	24.7
500	35.00	52.70	.229	91.40	105.20	.398	.458	68.46	78.72	.298	.342	25.1
1000	69.04	62 40	.272	122.90	141.50	.535	.615	86.80	100 00	.378	.435	29.4
1200	82.65	65.00	.283	132.00	151.80	.574	.661	91.20	105.00	.397	.456	30.8
1400	96.25	67.00	.292	140.00	161.00	.610	.702	95.50	109.90	.416	.478	31.8
1600	109.80	69.10	.301	147.50	169.00	.643	.740	98.80	113.80	.430	.495	33.1
1800	123.40	71.00	.309	154.00	177.00	.672	.773	102.20	117.70	.445	.512	33.9
2000	137 10	72.30	.315	160.50	185.00	.700	.805	104.50	120.20	.455	.524	35 0

ALTITUDE COMPRESSION.

HORSE-POWER DEVELOPED IN COMPRESSING ADIABATICALLY ONE CUBIC FOOT OF FREE AIR FROM ATMOSPHERIC PRESSURES AT ALTITUDES TO VARIOUS GAUGE PRESSURES—INITIAL TEMPERATURE OF AIR IN EACH CYLINDER 60° F., JACKET COOLING NOT CONSIDERED.

Altitude in Feet	ATMOSPHERIC PRESSURE		HORSE POWER DEVELOPED															
			SINGLE-STAGE COMPRESSION						TWO-STAGE COMPRESSION									
			Pounds Square Inch Gauge Pressure						Pounds Square Inch Gauge Pressure									
			60		80		100		60		80		100		125		150	
	Inches of Mercury	Pounds per Square Inch	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included	Theoretical	15% Friction Included
0	30.05	14.75	.1333	.1533	.1586	.1824	.1804	.2075	.1177	.1354	.1374	.1580	.1535	.1765	.1708	.1964	.1859	.2138
1000	28.91	14.19	.1314	.1512	.1562	.1797	.1775	.2043	.1158	.1332	.1350	.1553	.1507	.1733	.1676	.1927	.1823	.2096
2000	27.81	13.65	.1295	.1490	.1538	.1769	.1746	.2010	.1139	.1310	.1326	.1525	.1479	.1701	.1643	.1890	.1787	.2054
3000	26.75	13.13	.1276	.1469	.1514	.1742	.1717	.1978	.1120	.1288	.1302	.1498	.1451	.1669	.1611	.1853	.1751	.2012
4000	25.73	12.63	.1257	.1447	.1490	.1714	.1688	.1945	.1101	.1266	.1278	.1470	.1423	.1637	.1578	.1816	.1715	.1970
5000	24.75	12.15	.1238	.1426	.1466	.1687	.1659	.1913	.1082	.1244	.1251	.1443	.1395	.1605	.1538	.1779	.1679	.1928
6000	23 81	11 69	.1219	.1404	.1442	.1659	.1630	.1880	.1063	.1222	.1230	.1415	.1367	.1573	.1513	.1742	.1643	.1886
7000	22.92	11.25	.1200	.1383	.1418	.1632	.1601	.1847	.1044	.1200	.1206	.1388	.1339	.1511	.1480	.1705	.1607	.1844
8000	22.06	10.83	.1181	.1361	.1391	.1604	.1572	.1815	.1025	.1178	.1182	.1360	.1311	.1509	.1448	.1668	.1571	.1802
9000	21.25	10.43	.1162	.1340	.1370	.1577	.1543	.1782	.1006	.1156	.1158	.1333	.1283	.1477	.1415	.1631	.1535	.1760
10000	20.47	10.05	.1143	.1318	.1346	.1549	.1514	.1750	.0987	.1134	.1134	.1305	.1255	.1445	.1383	.1594	.1499	.1718
11000	19 74	9.69	.1124	.1297	.1322	.1521	.1485	.1717	.0968	.1112	.1110	.1277	.1227	.1413	.1350	.1557	.1463	.1676
12000	19.05	9.35	.1105	.1275	.1298	.1494	.1456	.1685	.0949	.1090	.1086	.1250	.1199	.1381	.1318	.1520	.1427	.1634
13000	18 39	9.03	.1086	.1254	.1274	.1466	.1427	.1652	.0930	.1068	.1062	.1222	.1171	.1349	.1285	.1483	.1391	.1592
14000	17.78	8.73	.1067	.1232	.1250	.1439	.1398	.1620	.0911	.1046	.1038	.1195	.1143	.1317	.1243	.1446	.1355	.1551
15000	17.21	8.45	.1048	.1210	.1226	.1411	.1369	.1588	.0892	.1024	.1014	.1167	.1115	.1285	.1221	.1409	.1319	.1508

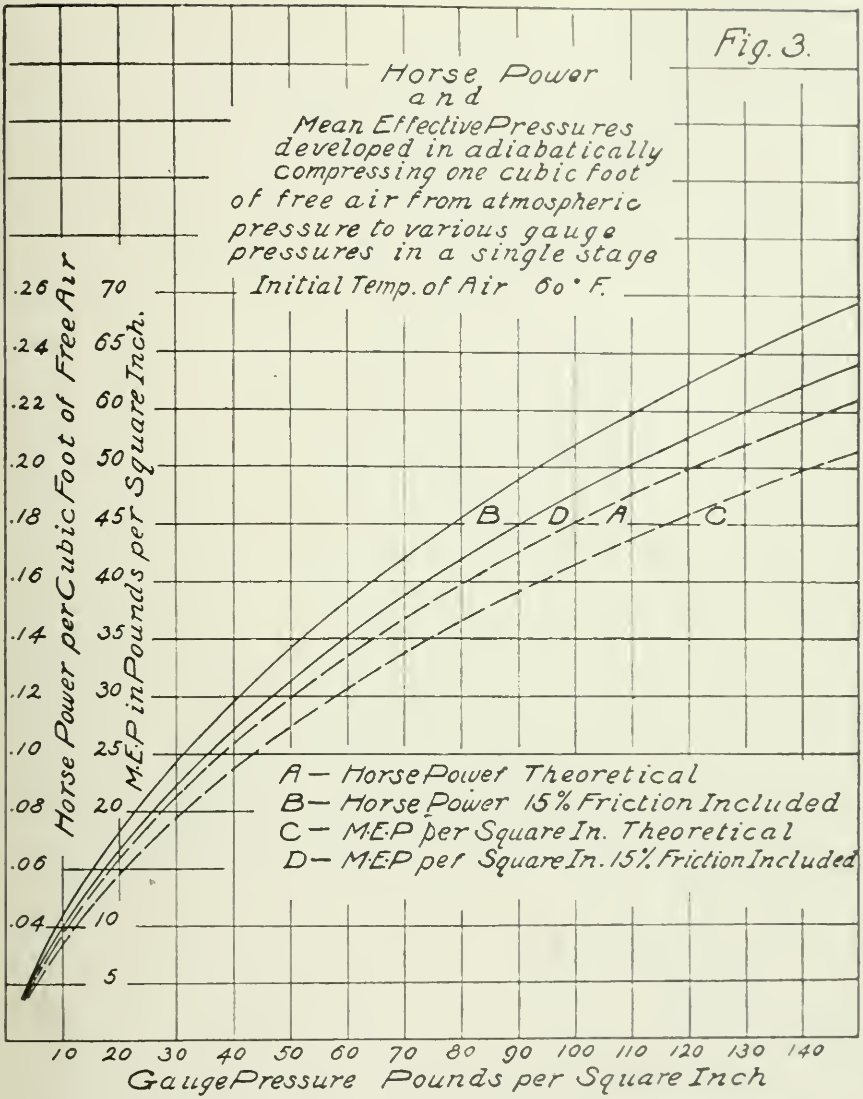
Fig. 3.
Horse Power
and
Mean Effective Pressures
developed in adiabatically
compressing one cubic foot
of free air from atmospheric
pressure to various gauge
pressures in a single stage
Initial Temp. of Air 60° F.
Horse Power per Cubic Foot of Free Air
M.E.P in Pounds per Square Inch.
.26 70
.24 65
.22 60
.20 50
.18 45
.16 40
.14 35
.12 30
.10 25
.08 20
.06
.04 10
5
B D A C
A — Horse Power Theoretical
B — Horse Power 15% Friction Included
C — M.E.P per Square In. Theoretical
D — M.E.P per Square In. 15% Friction Included
10 20 30 40 50 60 70 80 90 100 110 120 130 140
Gauge Pressure Pounds per Square Inch

E F Schaefer.

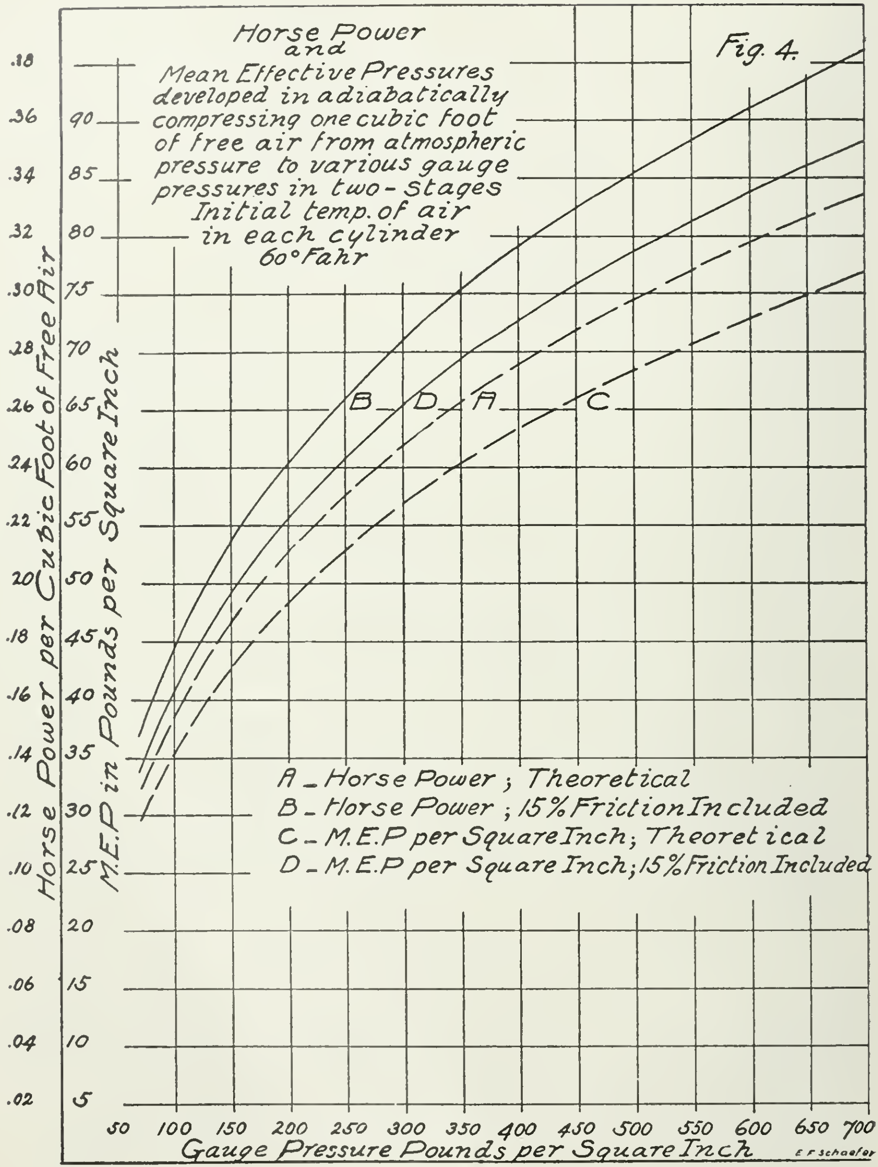

Fig. 4.

Horse Power and Mean Effective Pressures developed in adiabatically compressing one cubic foot of free air from atmospheric pressure to various gauge pressures in two-stages
Initial temp. of air in each cylinder 60° Fahr
Horse Power per Cubic Foot of Free Air
M.E.P in Pounds per Square Inch
.38
.36
.34
.32
.30
.28
.26
.24
.22
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
B
D
A
C
A – Horse Power; Theoretical
B – Horse Power; 15% Friction Included
C – M.E.P per Square Inch; Theoretical
D – M.E.P per Square Inch; 15% Friction Included
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Gauge Pressure Pounds per Square Inch
E F Schaefer

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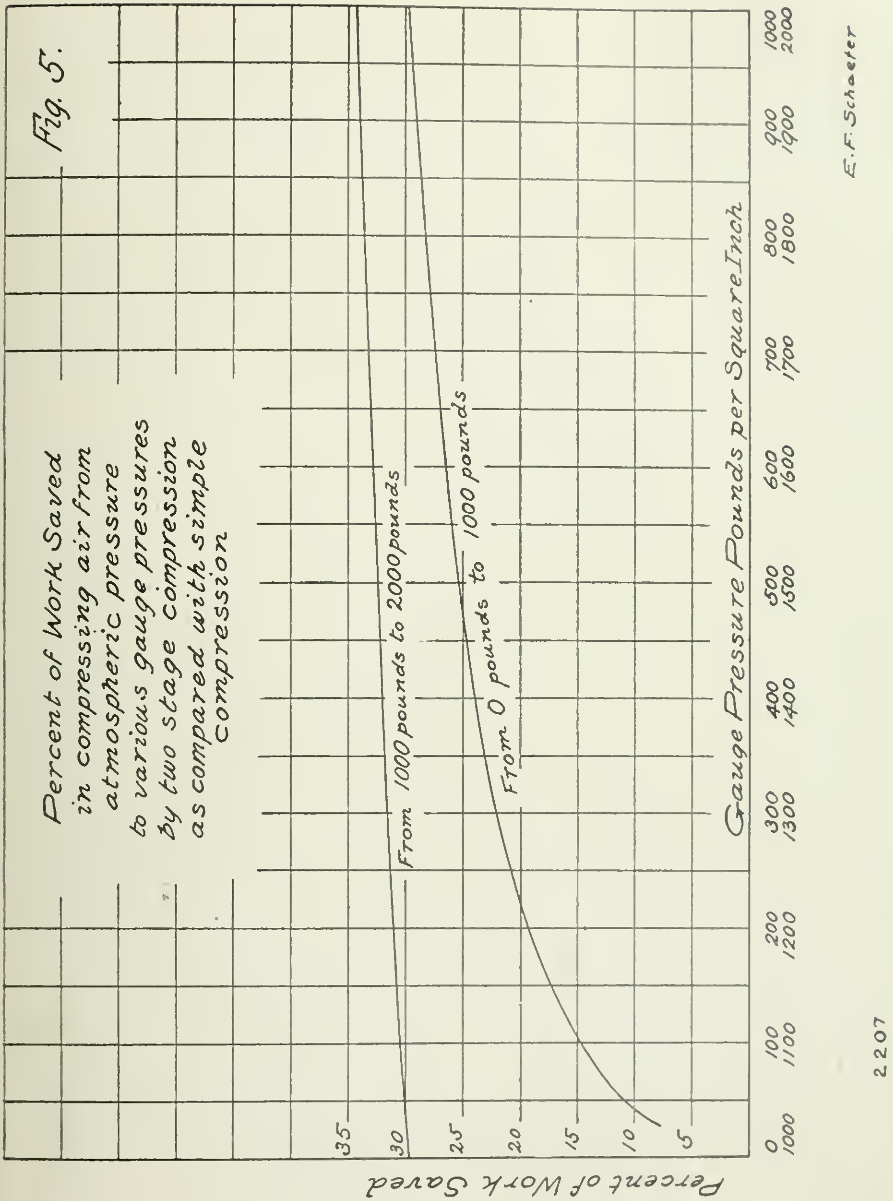

Fig. 5.

Percent of Work Saved in compressing air from atmospheric pressure to various gauge pressures by two stage compression as compared with simple compression

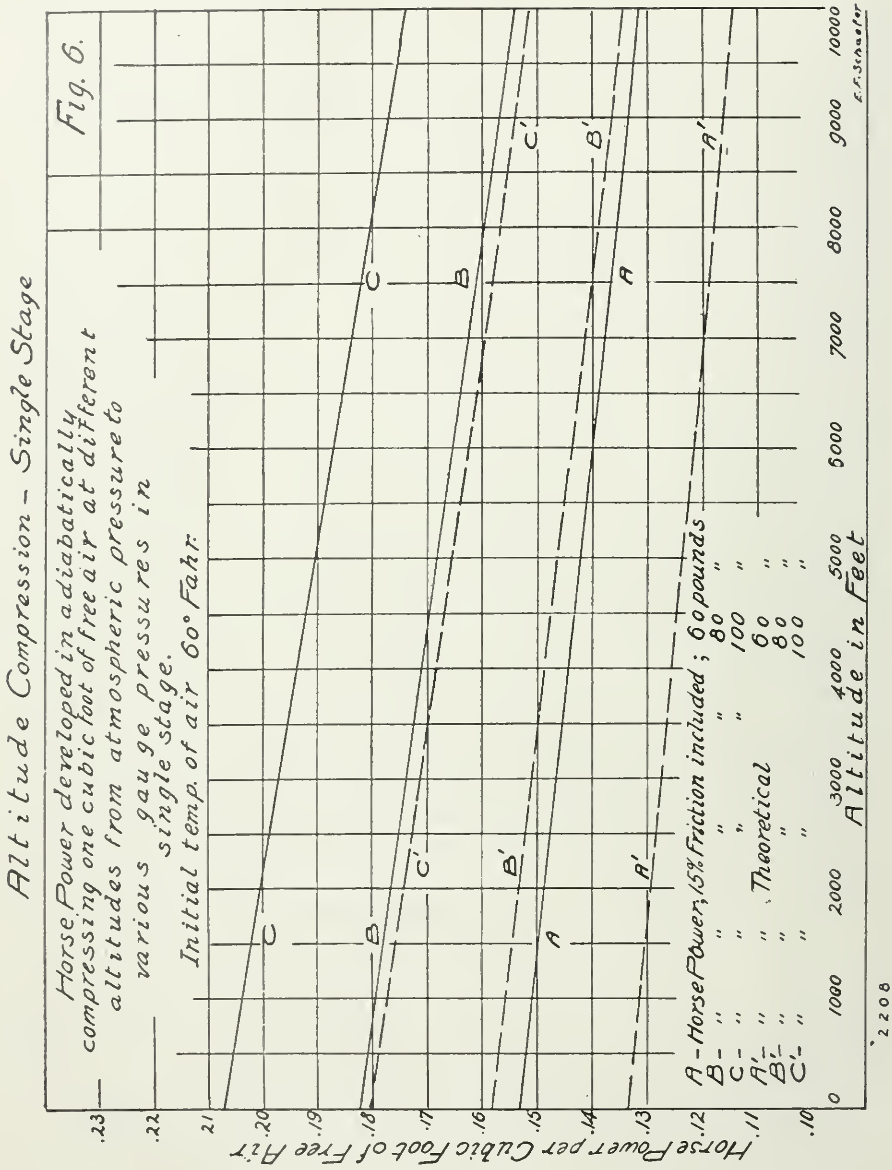

Fig. 6.

Altitude Compression - Single Stage
Horse Power developed in adiabatically compressing one cubic foot of free air at different altitudes from atmospheric pressure to various gauge pressures in single stage.
Initial temp. of air 60° Fahr.
A - Horse Power, 15% Friction included; 60 pounds
B - " " " " 80 "
C - " " " " 100 "
A' - " " Theoretical 60 "
B' - " " " 80 "
C' - " " " 100 "
A
B
C
A'
B'
C'
Horse Power per Cubic Foot of Free Air
.10
.11
.12
.13
.14
.15
.16
.17
.18
.19
.20
.21
.22
.23
Altitude in Feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
E. F. Schaefer
2208

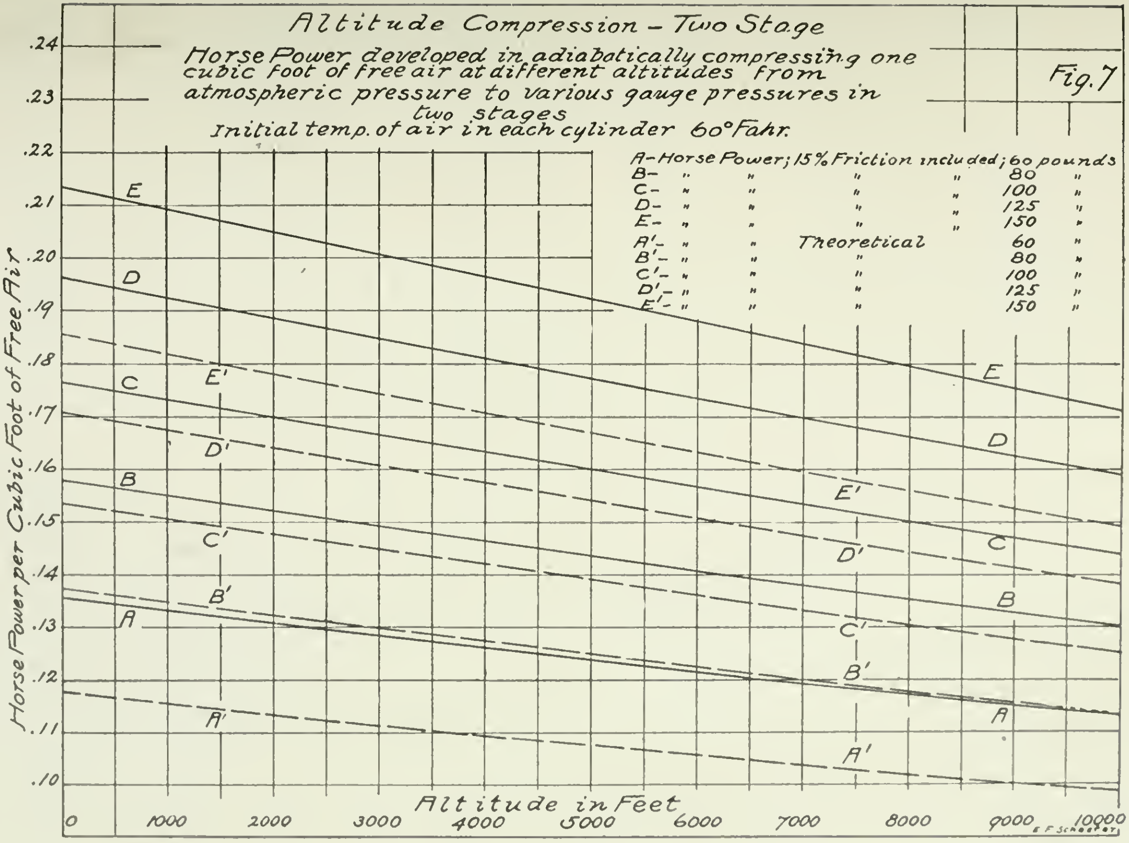

Fig. 7

Altitude Compression – Two Stage

Horse Power developed in adiabatically compressing one cubic foot of free air at different altitudes from atmospheric pressure to various gauge pressures in two stages

Initial temp. of air in each cylinder 60° Fahr.

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If the horse-powers for altitude conditions are required substitute in the above general formulae the proper altitude atmospheric pressure in place of 14.75.

Below are found formulae giving directly the horse-powers, for *altitude* conditions, for both theoretical and practical conditions. The only datum needed is the elevation in feet.

Let E = elevation in feet
HP_T = theoretical horse-power
HP_F = horse-power including 15 per cent. friction

Single Stage.

For 60-pound Gauge Pressure.

$$HP_T = 0.1333 - 0.0000019E$$
$$HP_F = 0.1533 - 0.00000215E$$

For 80-pound Gauge Pressure.

$$HP_T = 0.1586 - 0.0000024E$$
$$HP_F = 0.1824 - 0.00000275E$$

For 100-pound Gauge Pressure.

$$HP_T = 0.1804 - 0.0000029E$$
$$HP_F = 0.2075 - 0.00000325E$$

Two Stages.

For 60-pound Gauge Pressure.

$$HP_T = 0.1177 - 0.0000019E$$
$$HP_F = 0.1354 - 0.0000022E$$

For 80-pound Gauge Pressure.

$$HP_T = 0.1374 - 0.0000024E$$
$$HP_F = 0.1580 - 0.00000275E$$

For 100-pound Gauge Pressure.

$$HP_T = 0.1535 - 0.0000028D$$
$$HP_F = 0.1765 - 0.0000032E$$

For 125-pound Gauge Pressure.

$$HP_T = 0.1708 - 0.00000325E$$
$$HP_F = 0.1964 - 0.0000037E$$

For 150-pound Gauge Pressure.

$$HP_T = 0.1859 - 0.0000036E$$
$$HP_F = 0.2138 - 0.0000042E$$

The preceding formulae were employed in securing the data, represented in graphical form, in Fig. 3 to Fig. 7, inclusive.

Fig. 3 gives the mean effective pressures and horse-powers for single-stage operations in adiabatical compressing and in delivering one cubic foot of free air from atmospheric pressure to various gauge pressures. In these calculations it was assumed that the temperature of the intake air was 60 degrees Fahrenheit, which is the normal condition. Curve A given the theoretical horse-power necessary without considering fractional losses. In curve B, however, we find an allowance made for friction. The extra horse-power necessary when considering the work consumed by the movement of the piston, crosshead and crank-pins, etc., is less than 15 per cent., but we allow 15 per cent. to be on the safe side. Curves C and D represent the M. E. P. for theoretical and for frictional conditions, respectively.

Fig. 4 represents also the horse-powers and M. E. P.s for both theoretical and actual conditions. It is, however, devoted to two-stage compression and the initial temperature of the air, as it enters both the low pressure and high pressure cylinders, is taken as 60 degrees Fahrenheit.

Fig. 5 shows the per cent. of work saved in compressing air from atmospheric pressure to various gauge pressures by two-stage over simple compression. The values are found as follows:

Let a = work done in compressing in one stage to pressure p.
Let b = work done in compressing in two stages to pressure p.
Per cent. of power saved = $(a-b) \div a$.

Suppose, for example, that the per cent. of power saving is wanted when compressing to 100 pounds gauge. For 100 pounds we get from Fig. 3 0.207 horse-power, and from Fig. 4 we get 0.176 horse-power. Then $(0.207 - 0.176) \div 0.207 = 15$ per cent.

Fig. 6 gives the horse-powers necessary to compress one cubic foot of free air adiabatically at different *altitudes* from atmospheric pressure to various gauge pressures (60 pounds, 80 pounds and 100 pounds) in simple compression. Curves A, B and C include frictional losses and A^1, B^1 and C^1 are theoretical simply.

Fig. 7 is identical with Fig. 6, except that it is devoted to compound compression. The various terminal pressures are 60 pounds, 80 pounds, 100 pounds, 125 pounds and 150 pounds per square inch gauge.

The usefulness of the above formulae must now be apparent.

In addition to the foregoing solutions of the formulae expressing adiabatic conditions, it might also be of interest, as a basis of comparison, to know what forms the equations assume when compression is purely isothermal. The isothermal compression or expansion is the ideal. It is, of course, impossible, but the actual state is somewhere between the isothermal and adiabatic and usually close to the latter.

As we have to deal usually with work done in compression and transference, minus the work done by the atmosphere, the area or work is represented by the indicator card Fig. 8 and is expressed by:

$$\text{Work done} = CA^1FHC = ECA^1D^1 - ECB^1D^1 + (A^1FGD^1 - B^1HGD^1) \quad \ldots\ldots\ldots\ldots (16)$$

For isothermal compression:

$$pv = p_1 v_1 = p_2 v_2 = \&c. \quad \ldots\ldots\ldots\ldots (17)$$

$$p = \frac{p_1 v_1}{v}$$

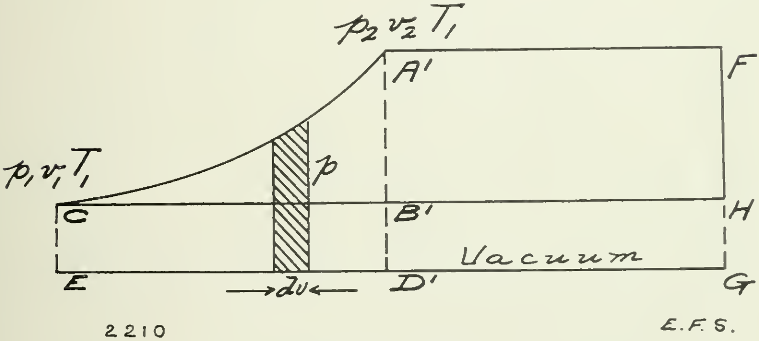

Fig. 8

From Calculus:

$$ECA^1D^1 = \int p\,dv \quad \ldots\ldots\ldots\ldots (18)$$

$$= \int \frac{p_1 v_1}{v}\,dv$$

$$= p_1 v_1 \int_{v_2}^{v_1} \frac{dv}{v}$$

$$= p_1 v_1 \log_e \left(\frac{v_1}{v_2}\right) \quad \ldots\ldots\ldots (19)$$

In which e is the base of the Naperian system of logarithms.

From (17)

$$\frac{v_1}{v_2} = \frac{p_2}{p_1}$$

Then:

$$ECA^1D^1 = p_1 v_1 \log_e \left(\frac{p_2}{p_1}\right) \quad \ldots\ldots (20)$$

$$= p_1 v_1 \times 2.3 \log \frac{p_2}{p_1} \quad \ldots\ldots (21)$$

Now:

$$\left.\begin{array}{l} p_1 v_1 = CHGE \\ p_2 v_2 = A^1FGD^1 \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (22)$$

and since $p_1 v_1 = p_2 v_2$ we have:

$$CHGE = A^1FGD^1$$

or

$$CHGE - B^1HGD^1 = A^1FGD^1 - B^1HGD^1$$

$$ECB^1D^1 = A^1FHB^1 \quad \ldots\ldots\ldots\ldots (23)$$

Substituting in (16)

$$\text{Work done} = CA^1FHC = ECA^1D^1 - ECB^1D^1 + A^1FHB^1 \quad \ldots\ldots\ldots (24)$$

$$\text{Work done} = CA^1FHC = ECA^1D^1 \quad \ldots (25)$$

and equating with (21)

$$\text{Work done} = 2.3\, p_1 v_1 \log \left(\frac{p_2}{p_1}\right) \quad \ldots\ldots (26)$$

Therefore, in isothermal compression the net work of compression and transference is equal to the total work of compression.

In isothermal compression the horsepower necessary per cubic foot of free air will be the same if we employ one, two, three or more stages in which to do the work.

Divide (26) by v_1 and the expression will represent the M. E. P. per stroke or

$$\text{M. E. P.} = 2.3\, p_1 \log\left(\frac{p_2}{p_1}\right) \ldots\ldots\; (27)$$

$$\text{H. P.} = \frac{144}{33000}\,\text{M. E. P.}$$

$$= 0.00436 \text{ M. E. P.} \ldots\ \ldots\ (28)$$

in which the pressures are reduced to pounds per square inch.

It is now my purpose to show that when air cylinders are proportioned according to the law

$$r_1 = r_2 = r_3 = \text{etc.} = r_n = \sqrt[n]{R}$$

the best conditions are possible and maximum saving in horse-power is the result. (Fig. 9.)

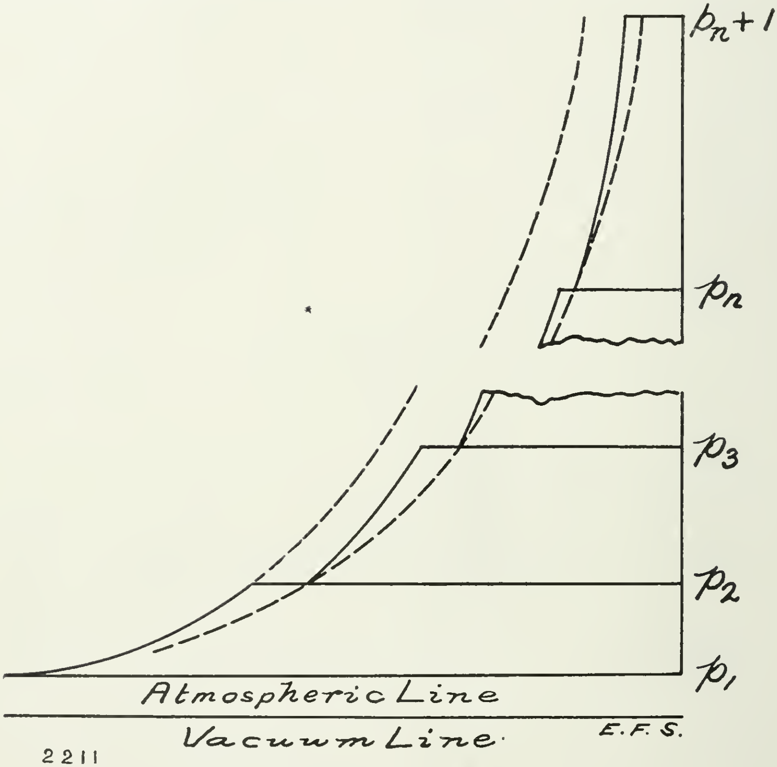

Fig. 9

Example III.

Required the horse-power necessary to compress isothermally one cubic foot of free air to 90 pounds per square inch gauge pressure.

p_1 = 14.75 pounds per square inch.
p_2 = 14.75 + 90 pounds per square inch.

$$\text{M. E. P.} = 2.3 \times 14.75 \times \log\left(\frac{104.75}{14.75}\right)$$

$$= 28.88$$

H. P. = 0.00436 M. E. P. = 0.1259 per cubic foot of free air.

Letting:

$$\frac{p_n + 1}{p_1} = R$$

$$\frac{p_2}{p_1} = r_1$$

$$\frac{p_3}{p_2} = r_2$$

$$\frac{p_n + 1}{p_n} = r_n$$

Assuming:

$$r_1 = r_2 = \text{etc.} = r_n = \sqrt[n]{R}$$

We have:

$$\frac{p_2}{p_1} \cdot \frac{p_3}{p_2} \cdots\cdots \frac{p_n + 1}{p_n} = \frac{p_n + 1}{p_1} = \mathrm{R}$$

$$r_1 \cdot r_2 \cdots\cdots r_n = \mathrm{R}$$

$$r_n = \frac{\mathrm{R}}{r_1^{\,n-1}}$$

$$r_3 = \frac{\mathrm{R}}{r_1^{\,n-1}}$$

$$r_2 = \frac{\mathrm{R}}{r_1^{\,n-1}}$$

From equation (12)

$$\mathrm{W}_{total} = 3.45\,p_1 v_1 (r_1^{0.29} - 1) + 3.45\,p_2 v_2 (r_2^{0.29} - 1) + \text{etc} + 3.45\,p_n v_n (r_n^{0.29} - 1)$$

$$\text{But } p_1 v_1 = p_2 v_2 = \text{etc} = p_n v_n$$

$$\begin{aligned}\mathrm{W}_{total} &= 3.45\,p_1 v_1 [(r_1^{0.29} - 1) + (r_2^{0.29} - 1) + \text{etc} + (r_n^{0.29} - 1)] \\ &= 3.45\,p_1 v_1 [r_1^{0.29} + r_2^{0.29} + \text{etc} + r_n^{0.29} - n] \\ &= 3.45\,p_1 v_1 [(n-1)\, r_1^{0.29} + \mathrm{R}^{0.29}\, r_1^{-(n-1)\,0.29} - n] \\ &= 3.45\,p_1 v_1 [(n-1)\, r_1^{0.29} + \mathrm{R}^{0.29}\, r_1^{0.29-0.29\,n} - n]\end{aligned}$$

$$\begin{aligned}\frac{d\,\mathrm{W}}{d\,r_1} &= (n-1)\,0.29\, r_1^{-0.71} + (0.29 - 0.29\,n)\, \mathrm{R}^{0.29}\, r_1^{-0.71-0.29\,n} = 0 \\ &= (0.29\,n - 0.29)\, r_1^{-0.71} - (0.29\,n - 0.29)\, \mathrm{R}^{0.29}\, r_1^{-0.71-0.29\,n} = 0\end{aligned}$$

Divide by $(0.29\,n - 0.29)\, r_1^{-0.71}$

$$1 - \mathrm{R}^{0.29}\, r_1^{-0.29\,n} = 0$$

$$\mathrm{R}^{0.29}\, r_1^{-0.29\,n} = 1$$

$$r_1^{-0.29\,n} = \frac{1}{\mathrm{R}^{0.29}}$$

$$r_1^{-0.29\,n} = \mathrm{R}^{-0.29}$$

$$r_1 = \mathrm{R}^{\frac{1}{n}}$$

$$r_1 = \sqrt[n]{\mathrm{R}}$$

$$\begin{aligned}\frac{d^2\,\mathrm{W}_t}{d\,r_1^2} &= -0.71\, r_1^{-1.71} - (-0.71 - 0.29\,n)\, \mathrm{R}^{0.29}\, r_1^{\;1.71-0.29\,n} \\ &= -0.71\, r_1^{-1.71} + (0.71 + 0.29\,n)\, r_1^{0.29\,n}\, r_1^{-1.71-0.29\,n} \\ &= -0.71\, r_1^{-1.71} + (0.71 + 0.29n)\, r_1^{-1.71} \\ &= -\frac{0.71}{r_1^{1.71}} + \frac{0.71 + 0.29\,n}{r_1^{1.71}}\end{aligned}$$

It is evident that the expression will always be positive. The differential is of an even order and positive showing.

$$r_1 = \sqrt[n]{\mathrm{R}}$$

corresponds to a minimum.

In other words, when:

$$r_1 = r_2 = r_3 = \text{etc} = r_n = \sqrt[n]{\mathrm{R}}$$

the work is equally divided between the cylinders and the maximum saving in power is effected.

RECAPITULATION.

p_i = absolute intake pressure in pounds per square inch.

p_t = absolute discharge pressure in pounds per square inch.

N = number of stages in which compression is to be accomplished.

M. E. $\mathrm{P._T}$ = theoretical mean effective pressure.

H. $\mathrm{P._T}$ = theoretical horse-power.

H. $\mathrm{P._F}$ = horse-power including 15 per cent. friction.

E = altitude in feet.

For Isothermal or Adiabatic Compression.

Horse-Power = 0.00436 M. E. $\mathrm{P._T}$ .....(A)

Isothermal Compression for any number of stages.

$$\text{M. E. P.}_{\mathrm{T}} = 2.3\, p_i \log\left(\frac{p_t}{p_i}\right) \ldots\ldots\ldots\ldots \text{(B)}$$

Adiabatic Compression.

For ONE stage

$$\text{M. E. P.}_{\mathrm{T}} = 3.45\, p_i \left[\left(\frac{p_t}{p_i}\right)^{0.29} - 1\right] \ldots\ldots \text{(C)}$$

For TWO stages

$$\text{M. E. P.}_{\mathrm{T}} = 6.90\, p_i \left[\left(\frac{p_t}{p_i}\right)^{0.145} - 1\right] \ldots\ldots \text{(D)}$$

For THREE stages

$$\text{M. E. P.}_{\mathrm{T}} = 10.35\, p_i \left[\left(\frac{p_t}{p_i}\right)^{0.097} - 1\right] \ldots \text{(E)}$$

For FOUR stages

$$\text{M. E. P.}_{\mathrm{T}} = 13.80\, p_i \left[\left(\frac{p_t}{p_i}\right)^{0.0725} - 1\right] \ldots \text{(F)}$$

For FIVE stages

$$\text{M. E. P.}_{\mathrm{T}} = 17\ 25\, p_i \left[\left(\frac{p_t}{p_i}\right)^{0.058} - 1\right] \ldots\ldots \text{(G)}$$

In general:

$$\text{M. E. P.}_T = 3.45\, Np_1 \left[\left(\frac{p_t}{p_i} \right)^{\frac{0.29}{N}} - 1 \right] \text{..(H)}$$

Adiabatic Compression for Sea Level Conditions.

For ONE stage

$\text{H. P.}_T = 0.10163\,(p_t^{\,0.29} - 2.183)$ ....(I)

For TWO stages

$\text{H. P.}_T = 0.30043\,(p_t^{\,0.145} - 1.477)$ ......(J)

For THREE stages

$\text{H. P.}_T = 0.51319\,(p_t^{\,0.097} - 1.297)$......(K)

For FOUR stages

$\text{H. P.}_T = 0.72983\,(p_t^{\,0.0725} - 1.216)$......(L)

In general:

$$\text{H. P.}_T = \frac{0.2218695\,N}{(14.75)^{\frac{0.29}{N}}} \left[p_t^{\frac{0.29}{N}} - (14.75)^{\frac{0.29}{N}} \right] \text{.(M)}$$

Adiabatic Compression for Altitude Conditions.

SINGLE STAGE.

For 60-pound Gauge Pressure.

$\text{H. P.}_T = 0.1333 - 0.0000019E$ ....(N)

$\text{H. P.}_F = 0.1533 - 0.00000215E$........(O)

For 80-pound Gauge Pressure.

$\text{H. P.}_T = 0.1586 - 0.0000024E$..........(P)

$\text{H. P.}_F = 0.1824 - 0.00000275E$........(Q)

For 100-pound Gauge Pressure.

$\text{H. P.}_T = 0.1804 - 0.0000029E$.........(R)

$\text{H. P.}_F = 0.2075 - 0.00000325E$........(S)

TWO STAGES.

For 60-pound Gauge Pressure.

$\text{H. P.}_T = 0.1177 - 0.0000038E$.........(T)

$\text{H. P.}_F = 0.1354 - 0.0000022E$ ....(U)

For 80-pound Gauge Pressure.

$\text{H. P.}_T = 0.1374 - 0.0000024E$..........(V)

$\text{H. P.}_F = 0.1580 - 0.00000275E$........(W)

For 100-pound Gauge Pressure.

$\text{H. P.}_T = 0.1535 - 0.0000028E$.........(X)

$\text{H. P.}_F = 0.1765 - 0.0000032E$.........(Y)

For 125-pound Gauge Pressure.

$\text{H. P.}_T = 0.1708 - 0.00000325E$.......(AA)

$\text{H. P.}_F = 0.1964 - 0.0000037E$........(BB)

For 150-pound Gauge Pressure.

$\text{H. P.}_T = 0.1859 - 0.0000036E$........(CC)

$\text{H. P.}_F = 0.2138 - 0.0000042F$........(DD)

Stage Compression.

Condition for best proportion

$r_1 = r_2 = r_3 = r_N = \sqrt[N]{R}$ ....(EE)

Compound Air Compression.

BY L. I. WIGHTMAN, E. E.

It is well known that the heating of air produces an increase in its volume, whatever the source of the heat. The heat produced in a cylinder by compression acts to expand the air in that cylinder, whatever the speed or rate of compression. In effect this is equivalent to an increase in the volume of air to be compressed and delivered. This in turn calls for an increase in the power, to compress this apparently added volume of air; or, to put it differently, the heat of compression, in increasing the volume of air, makes it necessary to carry the air to a higher mean effective pressure in the cylinder, in order to secure finally the required volume of air at the required pressure after its temperature has fallen to that of the surrounding atmosphere, requiring, therefore, an excess of power. A consideration of these facts suggests that if some means be provided for removing the heat of compression as fast as it is produced, there will be an important reduction in the power required to raise a given weight or volume of air to a given pressure.

When air is compressed in a cylinder without the removal or escape of any of the heat produced, the compression is known as "adiabatic." When compression is carried on in such a way that heat is removed as fast as produced, the compression is "isothermal." In the first case the air delivered under pressure will be at the high terminal temperature corresponding to that pressure. In the second, the compressed air will have the same temperature at which it entered the cylinder. Adiabatic compression is the kind which all pneumatic engineers seek to avoid, while isothermal compression is the impossible ideal. The actual results secured in the best compressors are intermediate between these, but nearer to the adiabatic.

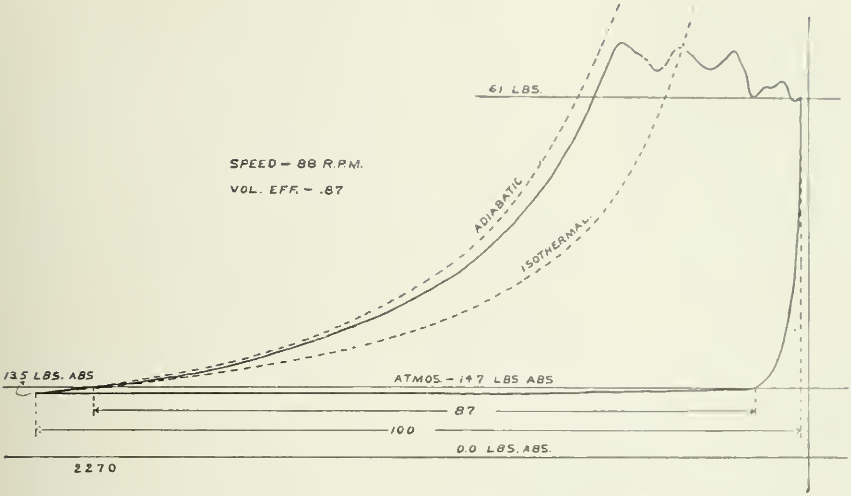

FIG. I. INDICATOR CARD FROM SINGLE-STAGE COMPRESSOR.

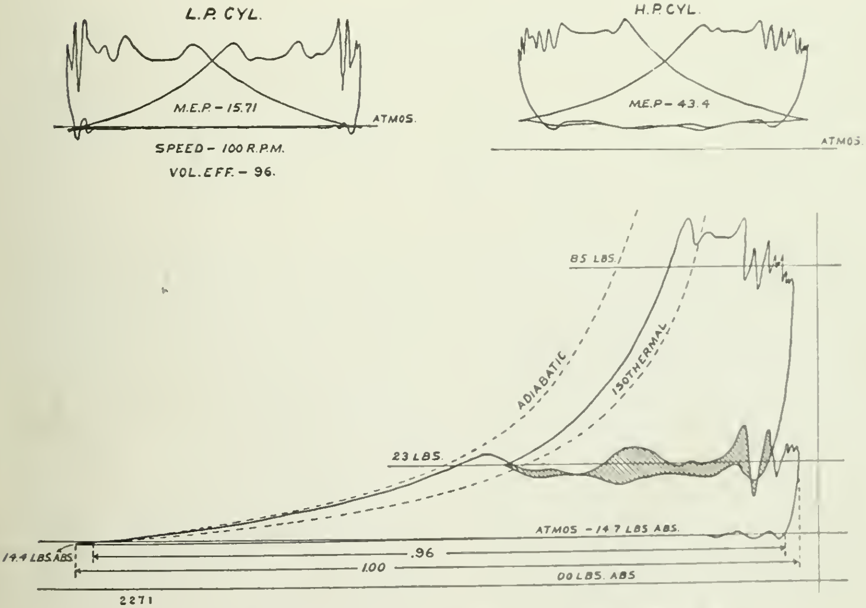

FIG. 2. INDICATOR CARD FROM TWO-STAGE COMPRESSOR O-A

Other things being equal, the economy of an air compressor depends on the proportion of the heat of compression which is removed as developed. Compressor efficiency, therefore, may be said to depend upon the effectiveness of the cooling devices adopted, provided what is gained here is not elsewhere wasted in whole or part. After long experience, bitter alike to makers and users, modern practice in compressor design recognizes only two practical methods of removing the heat of compression: jacket cooling and intercooling. These will be considered in order.

Jacket Cooling.—A brief consideration of the conditions will show that jacketed barrel cooling alone can be only a partial and very unsatisfactory solution of the problem of removing the heat developed by compression. With the piston at the beginning of its stroke, the maximum cold cylinder surface is exposed and the cylinder is filled with air at its lowest pressure and temperature. As the piston advances, pressure and temperature increase, while the effective area of cooling surface diminishes; and when the maximum pressure and temperature are attained near the end of the stroke, practically none of the cylinder wall is exposed except on the intake side of the piston; if the head is jacketed, it alone exerts any cooling influence. Furthermore, throughout the stroke only the outside layer of the air can be in contact with the cold surface and, air being a poor conductor of heat, none of the heat from the interior of the air volume is dissipated in the cooling water.

Cylinder jacketing is advisable and even essential for keeping the metal of the working parts at a low temperature, preventing the caking of lubricant upon the cylinder walls, and other evils of a hot machine. But it cannot of itself be considered as an adequate solution of the problem of cooling during compression. However, in constructions involving the use of a piston inlet tube and valve, not only the barrels, but the heads and discharge valves are chillled; and the piston and tube themselves are kept relatively cold. The air enters through a cold passage, is in contact on all sides with cold metal, and the maximum effects obtainable from jacketing alone are secured.

Intercooling.—If, at each of several points in the stroke the piston should be stopped for a moment and the air, already partially compressed and heated, be withdrawn long enough to be cooled by some external means to its initial temperature and then returned to the cylinder to be further compressed, it is evident that a fairly uniform temperature could be maintained in the air volume throughout the range of pressures from initial to terminal. The result would be in effect nearly that of isothermal compression. Evidently mechanical considerations forbid in practice such repeated starting and stopping of the piston; but the same results may be secured by carrying on the process of compression in several cylinders, in the first of which a certain low pressure is reached and the air at this pressure discharged through a cooling device to a second cylinder; there it is compressed to a still higher pressure and is discharged through another cooler to a third cylinder for further compression; and so on, until the required terminal pressure is secured. Such a process, developed to a practical working basis, is the method of compression in multi-stage cylinders which has become practically standard in air-compressor work for the higher pressures.

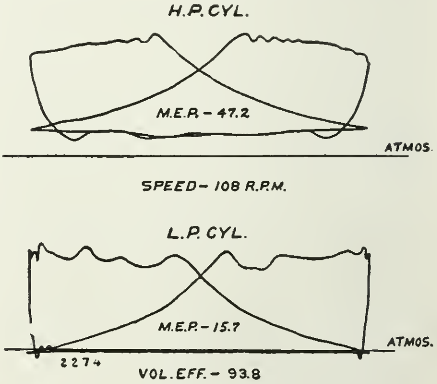

FIG. 3. CARDS FROM COMPRESSOR 9-A.

Multi-Stage Compression.—Theoretically, there is a gain in compound compression, whatever the pressure. But with low pressures the saving is so small as to be offset by the greater expense and complication involved in several cylinders and the losses unavoidable in the operation of added parts. After extended experience, makers of air compressors have fixed upon 70 pounds gauge pressure as the maximum terminal pressure which can be most economically obtained in a single cylinder; and for pressures from 75 pounds up, they have adopted compound compression in two, three and four stages, the number of stages increasing with the pressure. At high altitudes, however, with large volumes and expensive fuel, this dividing line may come at a lower pressure. It is elastic and depends somewhat on the conditions.

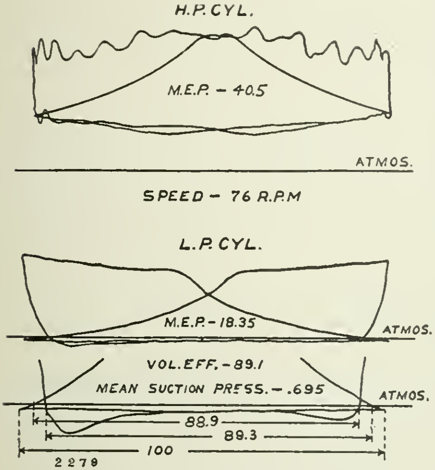

FIG. 4. CARDS FROM COMPRESSOR I-B.

In a compound air compressor, correctly designed, the cylinder ratios are such that the final temperature and total mean effective pressure are respectively the same in all cylinders, and all pistons are, therefore, equally loaded. The air compressed in the first cylinder to a pressure determined by the cylinder ratios is discharged through the outlet valves to an intercooler, where it is split up into thin streams passing over cold surfaces. The best practice provides a nest of tubes through which cold water circulates, and over and between which the stream of air passes, complete breaking-up and subdivision of the stream being secured by baffle plates and the tubes themselves. A properly designed intercooler having sufficient cooling area for the volume of air may reduce the temperature of the air compressed in the first cylinder to at least outgoing water temperature. From the intercooler this air, entering the second cylinder cold, is compressed to a higher pressure and again reaches a temperature nearly the same as that attained in the first cylinder In two-stage machines this air will be discharged directly to the receiver without further cooling unless conditions are such as to render advisable the use of an aftercooler. In three-stage machines the second cylinder is known as the intermediate, from which the air passes to the second intercooler to undergo a second reduction of temperature, and thence enter the third cylinder for final compression to required pressure.

It is evident that multi-stage compression is in effect identical with the theoretical process suggested above, in which the compressing piston was stopped and the air cooled at intervals during the stroke. The maximum cooling effect, and therefore saving, is secured by making the intercoolers of ample proportions and providing for the splitting up of the air stream into thin sheets exposed to cooling action.

The discussion thus far has dealt with the theory of compound air compression, the conditions encountered, and the means adopted in the best practice for meeting these conditions. General statements of the gains secured by compounding have been made. It remains to discuss in detail some of the more important and specific advantages arising from stage compression.

Reduced Power.—The accompanying table (1) gives the theoretical percentage of work lost in the heat of compression in one, two and four stages, at various pressures. In these figures no account is taken of jacket cooling, for the reasons already stated; nor is any allowance made for certain inevitable mechanical losses.

Taking a specific example, the saving by compounding strikingly appears. Assume that compressed air is to be delivered at a pressure of 100 pounds, and a rate equivalent to 100 final effective horsepower. Referring to the table, in the second column the theoretical percentage of lost work in one-stage compression is given at 38 per cent.; but, because there is bound to be some radiation of heat,

LOSS OF WORK DUE TO HEAT IN COMPRESSING AIR FROM ATMOSPHERIC PRESSURE TO VARIOUS GAUGE PRESSURES BY SIMPLE AND COMPOUND COMPRESSION.

AIR IN EACH CYLINDER ; INITIAL TEMPERATURE 60° F.

Gauge Pressure	One-Stage		Two-Stage		Three-Stage		Four-Stage	
	Percentage of Work Lost in Terms of							
	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression
60	29.9	23.0	13.4	11.8	8.6	7.9	4.7	4.5
70	30.6	23.4	14.1	12.4	8.7	8.0	6.1	5.7
80	32.7	24.6	14.7	12.8	9.7	8.9	6.4	6.0
90	34.7	25.8	16.1	13.8	10.5	9.5	7.3	6.8
100	36.7	26.8	16.9	14.5	10.9	9.8	7.8	7.3
125	41.1	29.2	18.5	15.6	11.6	10.4	8.8	8.1
150	44.8	30.9	20.1	16.7	12.3	10.9	9.1	8.4
200	51.2	33.9	22.2	18.1	14.0	12.3	10.5	9.5
300	61.2	37.9	25.7	20.5	16.6	14.2	12.0	10.7
400	68.7	40.7	28.9	22.4	18.2	15.4	13.1	11.5
500	70.6	41.4	31.2	23.8	19.3	16.2	14.1	12.3
600	80.4	44.5	32.8	24.7	20.4	16.9	14.9	13.0
700	85.0	46.0	34.6	25.7	21.3	17.6	16.1	13.8
800	89.5	47.2	35.7	26.3	22.0	18.1	16.2	13.9
900	93.0	48.2	37.1	27.0	22.6	18.5	16.6	14.4
1000	96.1	49.0	37.9	27.5	23.2	18.8	16.9	14.5
1200	102.8	50.7	40.3	28.8	24.8	19.9	17.7	15.0
1400	108.6	52.0	41.5	29.3	25.9	20.5	18.6	15.7
1600	113.4	53.1	43.5	30.3	26.5	20.9	19.2	16.1
1800	117.5	54.0	44.8	31.0	27.3	21.2	19.6	16.4
2000	122.0	55.0	45.8	31.4	27.5	21.5	19.9	16.5

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this value will not be found in practice and 30 per cent. may be assumed as a good practical value for the loss under average conditions. On this basis it is found, in the present case, that to deliver 100 horse-power in compressed air at 100 pounds pressure by one-stage compression, the compressor will require 130 indicated horse-power, ignoring mechanical losses. Looking now at column 4 of the table, the percentage of loss in two-stage compression at this pressure is found to be 17.1 per cent., which is very close to the value which will be found in practice. Applying this value, it is evident that to deliver the equivalent of 100 effective horse-power in air at 100 pounds pressure by two-stage compression, about 117 indicated horse-power will be required. In this case, as between single and two-stage compression, we have a direct saving in favor of the latter of 13 indicated horse-power or 10 per cent. Considering the compression of the same volume to the same pressure in four stages, the percentage of loss is seen to be 8 per cent. from column 6, implying an applied power of 108 indicated horse-power. In this case the saving, as compared to single-stage compression, is 24 horse-power, or 18½ per cent. From these gains something must be allowed for the friction of extra mechanical parts and of the air through additional sets of ports, valves, coolers, etc. More especially is this true when the machine belongs to that class of machines termed "compound" by courtesy, attractive in price through frugal designing, in which small coolers, insufficient valve area, the use of a hot discharge port for the air intake, small ports, etc., are all antagonistic to economy.

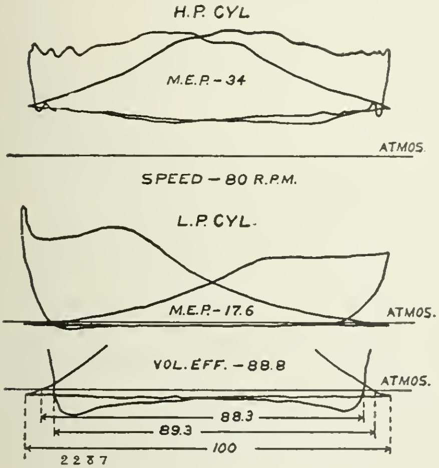


FIG. 5.

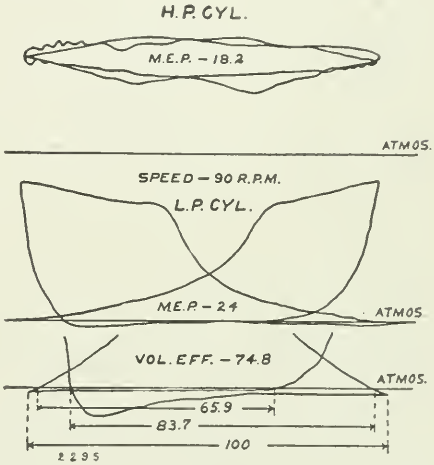


FIG. 6.

Authentic and repeated tests show that such machines may actually require 10 to 15 per cent. more power per cubic foot of air really delivered than some well designed simple single-cylinder types. No more cylinders are required for the compound than for the simple machine, in duplex constructions. Yet here, too, the economy expected is only realized from high-class designs, generously proportioned, and fitted with large coolers and the other essential refinements of good practice.

Reduced Strains.—When compression is carried on in a single cylinder, the difference between the pressures at the beginning and at the end of the stroke is the total difference between initial and terminal pressures, entailing a great variation in strains on the driving mechanism and the structure of the machine. The greatest strains come near the end of the stroke and are almost instantly relieved when the inlet valves open. Thus the terminal strain on a 20-inch cylinder having 314 square inches area, at 100 pounds pressure will be 31,400 pounds, or nearly 16 tons. At 100 revolutions this strain is repeated 200 times per minute and demands a very rugged construction. This is a condition not conducive to easy operation in any but the most massively proportioned compressors.

In compound compression, on the other hand, the difference between initial and terminal pressures in each cylinder is but a fraction of the total range of pressure. The pressures, furthermore, are partially balanced in the several cylinders. The working strains on valves and other parts are consequently greatly diminished, resulting in a greatly reduced wear and liability to breakage, and securing free lubrication and a noticeable improvement in the way of smooth, easy operation of the machine. These are all facts which contribute to continuous and satisfactory service, with the least possible adjustment and attention. As a matter of fact, compounding the air cylinders transfers so much of the load from the later to the earlier part of the stroke that the maximum terminal strain on bearings is reduced fully 45 per cent. over that in single-stage compression; in the above case, the reduction would be from 3,140 "ton-minutes" to 1,727—obviously a much easier proposition mechanically. Misled by this point, it has been common to reduce the weight and size of bearings accordingly—a mistake which will be evident when it is remembered that the stoppage of circulating water in the cooler at once raises the load on the low-pressure piston; while a broken or damaged outlet valve on the high-pressure cylinder may at any moment throw the same load on all parts as in a single-cylinder machine.

Improved Steam Economy.—The more equable distribution of the load throughout the stroke in compound compression, just noted, also aids in securing a higher economy in steam consumption at the lower end of a "straight-line" machine; for it makes possible an earlier cut-off in the steam cylinders and a consequently greater steam expansion with its attendant saving, late cut-offs not being so necessary to prevent "dead-centering." Multi-stage compression with effective intercoolers between stages also permits a higher piston speed, in itself a factor in steam economy in reducing the leakages and condensation in the steam end.

Higher Volumetric Efficiency.—The air remaining in the clearance space at the end of the stroke must be expanded on the return stroke to atmospheric pressure before free air can enter through the inlet valves. Evidently the higher the pressure in the clearance space, the greater will be the expanded volume, and the lower will be the intake efficiency of the cylinder. In single-stage compression the clearance pressure is the working pressure; in compound compression the clearance pressure in each cylinder is the terminal pressure in that cylinder. But this terminal pressure in the intake cylinder is low—usually not over 25 pounds per square inch when the final working pressure is 100 pounds. The volumetric efficiency of compound-compression cylinders is higher for this reason, the clearance in the low-pressure cylinder only being in question.

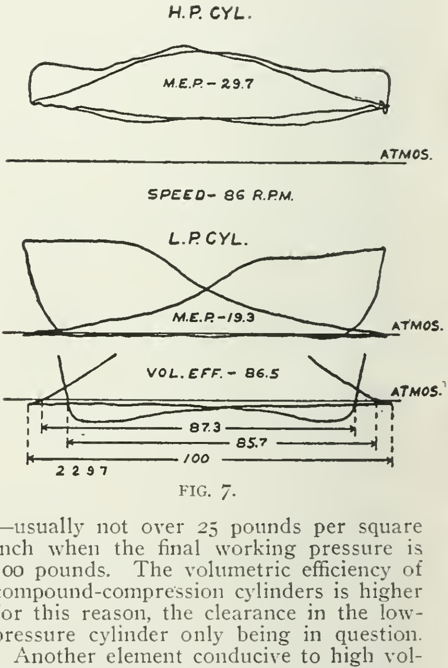


FIG. 7.

Another element conducive to high volumetric efficiency in compound compression is the fact that the terminal pressures, and consequently the terminal temperatures, are lower than in single-stage cylinders. The cylinder walls and, more particularly, the heads, together with the valves and ports which may be in them, are therefore kept much cooler and the entering air is not heated so much by contact with these parts. A third element entering into the question of efficiency is the reduced leakage through valves and past piston and rods, with the incidental loss of power. It is evident that the higher the pressure the greater the liability to leakage; and the small range of pressures in multi-stage cylinders reduces this loss.

Dryer Air.—One of the greatest difficulties hitherto encountered in air-power transmission has been the freezing of the moisture in the air, in the pipe line or at the exhaust ports of the air motors. One of the great advantages of the sub-division of compression into several stages lies in the opportunity it affords for cooling the compressed air at intermediate stages to a temperature at which its moisture will be precipitated. Of course practically all of this condensation occurs in the inter- and aftercoolers; and herein appears a necessity for a design which will pass the air at low velocity with full opportunity for cooling on the water tubes. The moisture in suspension is withdrawn through the drain pipe. It is needless to say that unless some provision is made for arresting and withdrawing the condensed water from the intercooler, the value of the latter as an air-dryer is lost: for the moisture is carried over into the compression cylinders, producing cutting and leakage and working out into the pipe line. Aftercoolers are in some instances as important as intercoolers in removing moisture.

Better Lubrication.—If air be compressed in a single cylinder from atmospheric pressure and temperature of 60 degrees Fahr. to a final pressure of 100 pounds, the maximum temperature attained may be 484 degrees Fahr. This temperature is manifestly destructive to common lubricants, and oils of ordinary quality are burned into a solid, gritty, coke-like or gummy substance, which gives the very reverse of proper lubrication. This deposit, moreover, collecting in ports and valves may so obstruct and clog them as to cause leakage and throw an added load on the compressor.

If, however, the same volume of air be compressed in the first cylinder to a pressure of 25 pounds, the highest temperature which can be reached is only 233 degrees—a heat which will not destroy the lubricating qualities of good oils such as should be used in compressor work. This air, passing through the intercooler, will be brought back to about the original temperature of 60 degrees and compressed, in a two-stage compressor, from 25 to 100 pounds in the second cylinder. Here the maximum temperature attained will be but little, if any, in excess of that in the first cylinder, since the heat of compression is a function of the number of compressions, and is almost wholly independent of the initial pressure. In multi-stage compressors, therefore the conditions of temperature are evidently most conducive to thorough lubrication of piston and valves, tending toward durability of working parts, with long life and high efficiency of the machine.

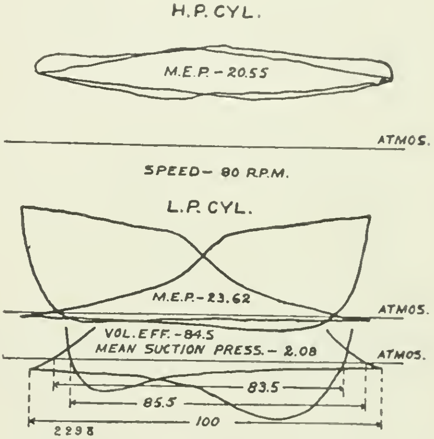


FIG. 8.

The advantages of compound air compression have gradually forced themselves upon the attention of pneumatic engineers. Not many years ago, when pressures were lower, the majority of compressors were single-stage machines. But with the growing tendency toward higher pressures, and an understanding of the needed economies, compound compressors came into greater prominence; and of late much the larger percentage of installations have been machines of this style.

But it will not do to reason that any compound compressor is necessarily more economical than a high-class simple machine, for such is not the case. On the contrary, only compounds of the highest class are advantageous from an economical standpoint. The gains depend not simply upon stage compression and effective cooling, but also upon correct design throughout the machine and a consistent attention to every detail. Every condition which may possibly affect the air from intake to discharge must be properly considered and provided for. Some of these defects which may offset compression economy have been noted at intervals throughout the preceding discussion. But their importance merits a repetition of them here. A weak structure and insufficient bearings (based on a mistaken idea of reduced strains), with no provision for unexpected contingencies, resulting in excessive friction losses; multiplicity of wearing parts, absorbing a large portion of the power theoretically saved; heated and restricted air passages, inefficient valves, neglect of proper jacket and head cooling; small and ineffective intercoolers; poor workmanship, resulting in leakage losses.

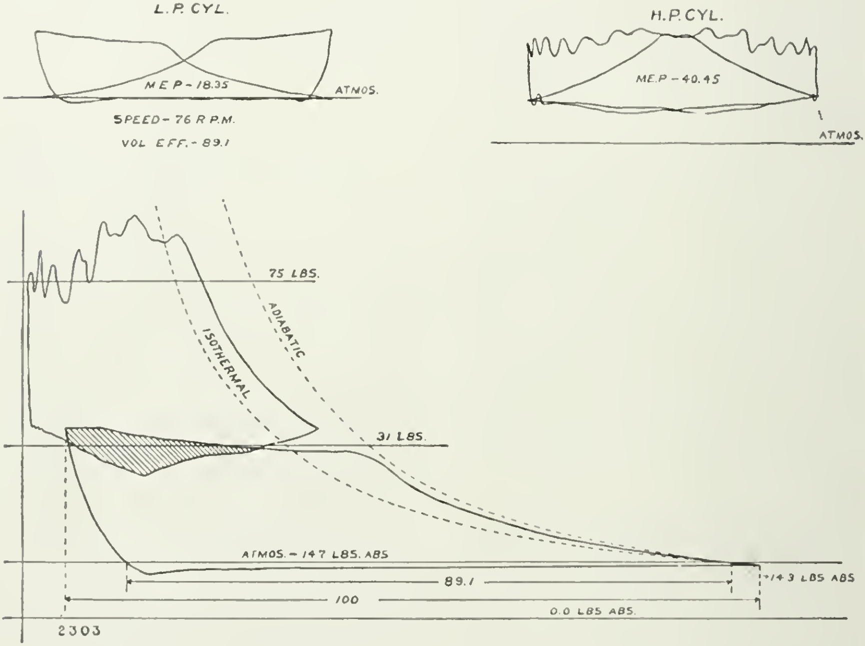


FIG. 9.

Not only may the enumerated defects largely offset the saving by compression in stages, but it is a fact that compounds now on the market may require more power per cubic foot of air compressed than well-designed, high-class, simple compressors of equivalent capacity. This latter statement embodies so great an apparent engineering heresy as to demand a strong substantiation in fact. For this reason the following test is reported. For obvious reasons the names of the makers of the compressors in question are withheld. It may be stated here, however, that the machines are standard types of American builders of established reputation at home and abroad; the two manufacturers have been distinguished by the terms "Maker A" and "Maker B." The object of the tests was primarily to ascertain the comparative economies of compound compressors of average type and simple machines of the highest grade, more especially under practical conditions of continuous use.

To make the tests fair and representative, compressors in actual service were selected and those tested have been in

TABLE 2. SINGLE-STAGE AIR COMPRESSORS—"MAKER A"

Machine No.	1A.	2A	3A.	4A.	5A.
Diameter air cylinder, inches	26	26	26	26	26
Diameter steam cylinder, inches	24	24	24	24	24
Stroke, inches	30	30	30	30	30
Speed, R. P. M.	88	80	84	60	80
Mean net area—air cylinder	519.8	519.8	519.8	519.8	519.8
Air cylinder displacement	1,590	1.145	1.518	1,080	1.145
Free air shown by L. P. card	1.383	1,285	1 324	973	1,250
Volumetric efficiency, %	87	89.1	87.4	91	86.5
Receiver pressure	61	60	61	92.5	95
Horse-power, Air cylinder	201.5	185	192	171	223.5
Air horse power per 100 cu. ft. free air	14.51	14.4	14.5	17.6	17.86
Computed horse-power per 100 cu. ft. adiabatic comp	13.5	13.35	13.5	17.3	17.52
Efficiency compared with perfect one-stage comp., %	93	92.8	93 2	98.4	98.2
Computed horse-power per 100 cu. ft. perfect two-stage comp.	11.9	11.8	11.9	14 83	15 05
Efficiency compared with perfect two-stage comp., %	82	82	82.1	81 5	84.3
Indicator Card	Fig. 1	Fig. 1			

TABLE 3. TWO-STAGE AIR COMPRESSORS—"MAKER A."

Machine No.	6A.	7A.	8A.	9A.
Diameter L. P. air cylinder, inches	20	20	15	26
Diameter H. P. air cylinder, inches	13	13	10	16
Diameter steam cylinder, inches	18	18	14	24
Stroke, inches	18	18	14	24
Speed, R. P. M.	100	80	155	108
Mean net area L. P. air cylinder	308	308	171 53	515
Mean net area H. P. air cylinder	132.46	132.46	78.54	198.15
L. P. cylinder displacement	642	513	430	1,545
Free air shown by L. P. card	616	495	398	1,448
Volumetric efficiency, %	96	96.4	92.6	93.8
Intercooler pressure	23	23	22	25
Receiver pressure	85	82	90	90
Horse-power L. P. air cylinder	44	35	28	106
Horse-power H. P. air cylinder	52.25	40.1	35.8	122.8
Total air horse-power	96.25	75.1	63.8	228.8
Air horse-power per 100 cu. ft. free air	15.6	15.15	16	15.82
Computed horse-power per 100 cu. ft. two-stage comp	14.22	13.92	14.71	14.7
Efficiency compared with perfect two-stage comp., %	91.25	92	92	93
Indicator Cards	Fig. 2			Fig. 3

TABLE 4. TWO-STAGE AIR COMPRESSORS—"MAKER B."

Machine No.	1B.	2B.	3B.	4B.	5B.
Diameter L. P. air cylinder, inches	28	28	28	28	26
Diameter H. P. air cylinder, inches	17½	17½	17½	17½	17½
Diameter steam cylinder, inches	28	28	28	28	24
Stroke, inches	30	30	30	30	30
Speed, R. P. M.	76	80	90	86	80
Mean net area L. P. air cylinder	611.9	611.9	611.9	611.9	527.4
Mean net area H. P. air cylinder	231.9	231.9	231.9	231.9	231.2
L. P. cylinder displacement	1.618	1,700	1.915	1,830	1.465
Free air shown by L. P. card	1,110	1,510	1,430	1,580	1,240
Volumetric efficiency, %	89.1	88.8	74.8	86.5	84.6
Intercooler pressure	31	28	50	33	31
Receiver pressure	75	64	68	58	55
Horse-power L. P. air cylinder	129	130.8	200	154	151
Horse power H. P. air cylinder	108	95.4	57.5	89.5	57.5
Total air horse-power	237	226.2	257.5	243.5	208.5
Air horse-power per 100 cu. ft. free air	16.45	15	18	15.4	16 82
Computed horse-power per 100 cu. ft. two-stage comp	13.3	12 28	12 7	11.62	11.27
Efficiency compared with perfect two stage comp., %	80.9	81.8	70.5	75 5	67
Indicator Cards	Fig. 4 Fig. 9	Fig. 5	Fig. 6	Fig. 7	Fig. 8

operation for from two to fourteen years under average working conditions and average attendance. But the results showed up the compounds in such an unfavorable light, that it was determined to continue the investigation, to include compounds of the same grade of workmanship and the same make as the simple machine tested. However, no old compressors of this type were available, so new machines were tested at the builder's shops, just before shipment. The conditions in all tests were made as nearly identical as possible and the results show in a striking manner the effect of correct design and workmanship on compressor efficiency.

The thing which appeals to the buyer is the economy of the machine he purchases —the saving he will secure by its use. In an air compressor, two distinct efficiencies are to be considered; the volumetric efficiency, or ratio of actual to theoretical air capacity; and the compression efficiency, or ratio of actual power required to the theoretical. To facilitate comparison in the present case, the several values from the preceding report are here grouped and averaged:

VOLUMETRIC EFFICIENCIES.

"Maker A," two-stage—96, 96.4, 92.6 and 93.8 per cent.; average, 94.7.
"Maker A," single-stage—87, 89.1, 87.4, 91 and 86.5 per cent.; average, 88.2.
"Maker B," two-stage—89.1, 88.8, 74.8, 86.5 and 84.6 per cent.; average, 84.76.

It here appears that the high-grade two-stage compressors of "Maker A" suffer an average loss in capacity of only 5.3 per cent. of the theoretical: the high-grade single-stage machines lose on the average only 11.8 per cent. of the theoretical capacity; while the ordinary two-stage compressors of "Maker B" lose an average of 15.24 per cent. of their theoretical air displacement. High-grade workmanship and correct design, therefore, effect in these instances an average saving in air capacity of 9.94 per cent. in the two-stage types and 3.44 per cent. in single-stage machines.

COMPRESSION EFFICIENCIES.

"Maker A," two-stage—91.25, 92, 92 and 93 per cent.; average, 92.06.
"Maker A," single-stage—82, 82, 82.1, 84.5 and 84.3 per cent.; average, 82.98.
"Maker B," two-stage—80.9, 81.8, 70.5, 75.5 and 67 per cent.; average, 75.14.

The high-grade compounds waste but 7.94 per cent. of the theoretical power required; the single-stage machines of the same grade lose 17.02 per cent.; while the ordinary two-stage compressors of "Maker B" waste 24.86 per cent. of the power applied to them.

The striking feature of this is the enormous waste in the compounds of "Maker B," due to defects such as have been briefly suggested. These losses have more than offset the advantages of compounding. Even the single-stage machines of "Maker A" show an average superiority of 7.84 per cent. over these defective compounds, while comparison of the two two-stage types shows an average advantage of 16.92 per cent. in favor of "Maker A's" high-class machines, correctly designed and properly proportioned for the duty.

Compression efficiencies for "Maker A's" single-stage machines, in the last line of the table, are referred to perfect two-stage compression, simply for ready comparison with the compound machines. It is to be noted that the efficiency of these compressors compared to perfect one-stage compression is also given as follows: 93, 92.8, 93.2, 98.4 and 98.2 per cent.; average, 95.12. This means that on the average these machines depart less than 5 per cent. from theoretically perfect performance in their type. Such efficiencies indicate a remarkable refinement in design and workmanship and exemplify the importance of the care bestowed upon what are usually considered minor details.

The term "compound" or "two-stage" as applied to air compressors should properly stand for superior economy. The buyer of a compound rightfully expects a saving by its use. The foregoing tests, taken without prejudice from average machines in ordinary practice, indicate how even reputable builders, acting no doubt in all good faith, may furnish a compressor which may prove a veritable "gold brick" in the hands of the trusting purchaser. Poor practice may prove the undoing of the best theory. That compressor only is a commercial and economical success which embodies a sound theory in a mechanical structure correctly designed, built by skilled and careful workmen, and so simple as to be readily understood, handled and maintained by mechanics of average intelligence.

Wet vs. Dry Compressors.

BY J. WALTER PEARSE.

So early as 1867 the late Professor Mallard, of the Paris School of Mines, pointed out that water in compressing cylinders causes a notable diminution of the energy to be expended, and a considerable lowering of the air temperature. This temperature, while being scarcely 50 degrees cent. (122 Fahr.) in wet compressors, attains as much as four times that figure in the dry variety, which is one of their inherent disadvantages, alone sufficing to determine the adoption of compression in stages. The Professor also showed that the quantity of water to be introduced is slight, but that there is no great disadvantage in employing a slight excess of water, the quantity of which can easily be determined for each compressor.

It may be added (observed M. J. Francois, at the Liege Mining Congress) that the introduction of water into the cylinders requires the use of valves with hydraulic joints, which are far more efficient than those with dry joints. To have a just idea of this, it is necessary to determine the relative speed of the water and compressed air, which flows off freely through one and the same orifice, and also to consider that the volume of the compressed air leakage must be multiplied by $\frac{P_1}{P_0}$ (P_0 and P_1 representing the respective pressures of the air on entering and leaving the compressor) at any rate, for the leakage which occurs during aspiration, this being necessary for determining the influence of the leakage, not only on the volumetric yield, but also on the dynamic yield, seeing that in this case the loss is of compressed air.

Water introduced into compressors, provided it be recuperated and used over again, after being passed through a refrigerator along the return pipe, becomes absolutely neutral and incapable of causing injurious incrustations on valves, pistons and cylinders, even if the water at disposal be not of the best quality. Moreover, if a little soft soap be added to the water it will, of itself, be sufficient to lubricate the pistons and cylinders.

Nor should it be forgotten that the water is drawn along in the state of steam through the pipes leading underground, and, owing to the fact that such steam is produced by the heat disengaged from the air during its compression, the quantity of water thus lost will always be very slight. From the heat due to the compression must be deducted that lost in the water recovered, as also the loss owing to the cooling action of the compressing cylinders.

The author brings figures to show that in a compressor of 100 indicated horsepower, even supposing that all the heat engendered by the compression vaporizes the water, less than half a litre (or not a pint) of water is thus lost per horsepower per hour, while this very slight quantity is a maximum which is far from being actually attained.

The disadvantage sometimes attributed to dampness in compressed air, as regards its freezing in the motors, is negligible, because it may be avoided by previously determining the space to be left free between piston and cylinder cover, and so regulating the distribution of compressed air as to obtain the desired compression in this space. Such practice, the advisability of which may be proved mathematically, prevents the formation of hoar-frost inside the motors, and it causes no loss of power, because that absorbed in compression is at once given back.

In any case, whether the compressor be wet or dry, M. Francois advocates making the delivery passages as short as possible, and only employing for cylinder lubrication such oils as are used in ice-making machines, while in large motors the compressed air should be delivered into a wooden "snow-box" by pipes leading sufficiently far from the motor to preserve it and the driver from an icy cold.

His conclusions are that, although air compression can be effected by both dry and wet compressors, the latter have great advantages, both in single stage and multiple compression. In point of fact, if a comparison be made between the two methods now almost exclusively employed—multiple compression in dry compressors and direct compression in wet compressors—it will be found that the former has a certain advantage as regards the dynamic yield, although the extent of this advantage has been somewhat exaggerated.

The author's examination of the results shown by indicator diagrams in the two methods of compression, up to 6 and also up to 7 atmospheres, shows that in the first case. for the compression of a cubic metre of natural air, a work of 26,050 kilogram metres is required by direct compression in a wet compressor, of 24.000 kilogram metres by dry compound compressors, showing an advantage of 7.8 per cent. in favor of the latter, while in the second case (compression to 7 atmospheres), the economy will be 28,300 — 25.925 — 2.375 kilogram metres, or 8.7 per cent.

Accordingly, this is the only advantage of dry multiple compression over wet direct compression for pressures not exceeding those adopted in mines, and it must be added that this advantage is set off by the complication of the two stages.

Air Compressor at the Champion Copper Mine, Painesdale, Michigan.

The mining of copper is probably the most expensive form of mineral production; and of all copper mines, those of the "copper country" of Lake Superior have the highest operating cost. Low-grade values, extended deposits, and immense depths make mining costs high and necessitate the most economical methods of operation to keep these properties in the favored list of dividend payers.

Among the twenty-two producing mines of the Lake Superior district the "Champion" ranked fifth in production in 1904, being credited during that year with an output of 12.500.000 pounds of refined copper, the sale of which yielded dividends of $300,000. The mine is at Painesdale, Mich., and is one of several large properties owned and operated by the Copper Range Consolidated Copper Company. Under present average conditions of operation its output is about 2,000 tons of ore per day, which is hoisted through four shafts well scattered over the extensive property.

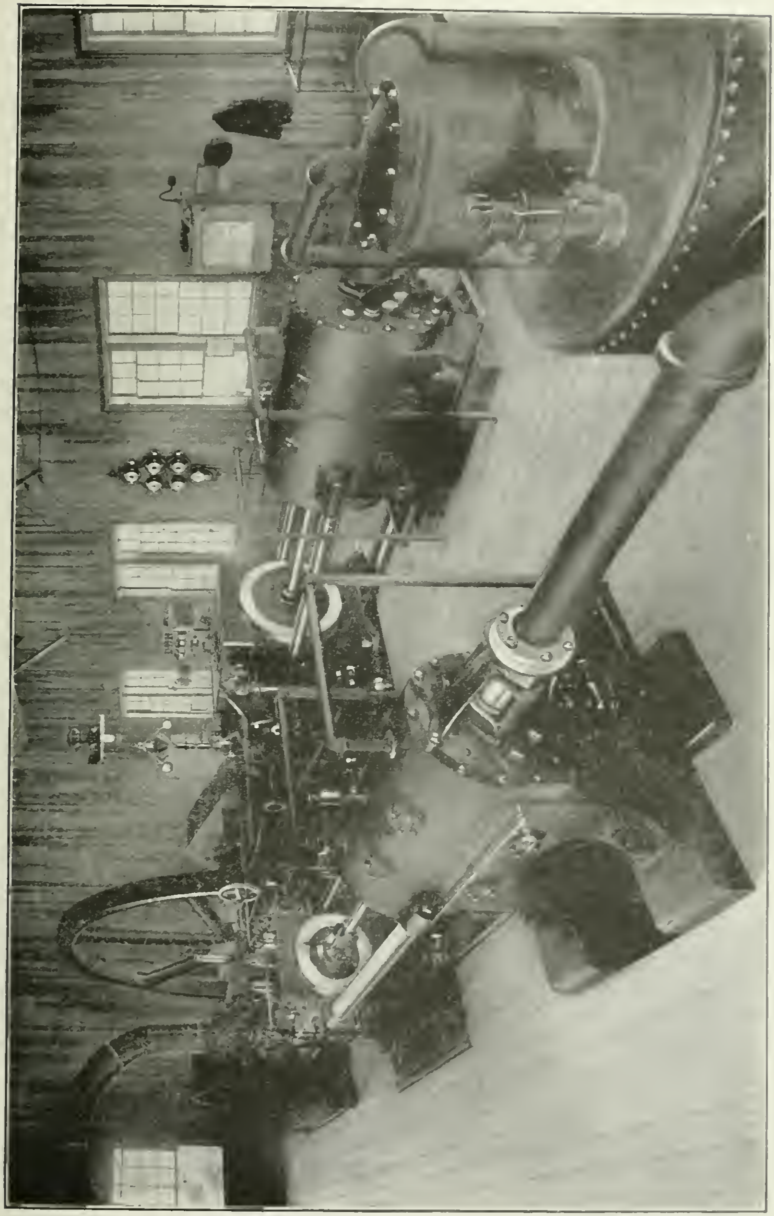
High-grade machinery equipments are characteristic of Michigan copper mines, and the "Champion" is no exception. Cheap power is but one factor in securing the low operating cost made necessary by mining conditions. Machine methods rule and the rock drill is monarch of the situation. The air power plants of these mines are the key to their successful operation, and that of the "Champion" is typical of the high standard of economy maintained.

One of the largest compressors in the district is located on this property and was built by the Ingersoll-Sergeant Company, of New York. It is a duplex Corliss type with cross-compound condensing steam cylinders and two-stage air cylinders. Steam is supplied at 130 pounds pressure by a battery of high pressure boilers in an adjacent boiler house. The steam pipe enters the basement of the compressor house and rises through the engine room floor to the high-pressure steam cylinder with a wide sweep bend of 6-inch pipe. The exhaust passes to a Worthington condenser, located, with its pumps, in the basement below. A vacuum of about 20 inches is maintained. The steam-valve gear is of standard Corliss release type. Automatic regulation is secured by an improved governor, in which the usual fly-balls are supplemented by a governor cylinder through which receiver air pressure operates to vary the cut-off on both cylinders, adjusting the speed to the demand for air and maintaining air pressure constant. Main frames are of standard heavy-duty tangye pattern, and cranks are of balanced disk type.

High and low-pressure air cylinders are completely water-jacketed on heads and barrels. Cold air is drawn from outside the building through a duct terminating in an intake bracket supported on the compressor foundation. The . Sergeant piston inlet valve handles the intake on both high and low-pressure cylinders. Direct-lift discharge valves are used. A vertical receiver intercooler stands between the cylinders, 48 inches in diameter and 13½ feet high, with tinned brass tubes through which the cooling water circulates.

Steam cylinders are 18 and 36 inches in diameter; air cylinders. 20¼ and 32¼ inches. The stroke is 48 inches. Normal speed is 72 revolutions per minute, at which the free air capacity of the compressor is 3.100 cubic feet per minute. Air pressure is 80 pounds.

The compressor building is an iron-covered steel-framed structure lined with sheathing and floored with matched wood. A solid concrete foundation capped with



AIR COMPRESSORS IN THE POWER HOUSE AT PAINESDALE, MICH.

finished stone supports the compressor. The illustration shows the interior of the engine-room with the intercooler in the right foreground. The stairway on the right leads to the basement, which contains all auxiliaries, beside an engine-driven generator for lighting purposes.

In a separate building, close at hand, is another Ingersoll-Sergeant air compressor—a survivor from early days of the "Champion" mine. At one time this small machine furnished all the air required for rock drills; to-day it is maintained as an auxiliary to the larger compressor. It is a straight-line type, steam-driven, with simple steam and air cylinders, 18 and 18¼ inches in diameter, respectively, and a stroke of 24 inches. At the rated speed of 94 revolutions per minute its free air capacity is 656 cubic feet per minute, delivered at 80 pounds pressure. The steam end is fitted with adjustable cut-off valves of Meyer type; and Sergeant "piston inlet" and direct-lift discharge valves handle admission and discharge of air.

There was a period of two years in the history of the "Champion" mine when rapid development threw an unusually heavy load on these two compressors—the Corliss and straight-line. During this time these machines ran continuously, 24 hours per day and 7 days in the week, carrying, jointly, an average load of 56 rock drills, 7 pumps and 4 "puffers"—small hoists used for light work. Throughout all this heavy overload there were no breakages and no repairs on the compressors, nor any delay directly chargeable to these machines. They came through the ordeal in splendid condition. Now that conditions are somewhat relieved the larger compressor easily does the work of its section of the mine, while its smaller associate stands ready for emergencies.

Air Required to Operate Rock Drills.*

The first thing to consider when about to install compressed air to operate rock drills is the number and sizes of the drills required to do the work. This means the total number of drills that will be in active service at one time.

The size of the drills is determined by the material to be drilled, whether soft, medium, or hard, together with the depth that it is desired to drill the holes.

The number of drills to use is decided by the rapidity with which the work is to be done, the feasibility of working more or less drills at different points to advantage, etc.

When the maximum number to be run is determined, the question arises as to what capacity of compressor is needed to drive them. This depends greatly on the air pressure to be used, which varies from 60 pounds to 100 pounds in different plants; the lower the air pressure, the less the amount of air required. For use at sea level, probably 80 pounds is the most common pressure at the present time. This seems to be the pressure that gives the best results under average conditions, but the kind of rock to be drilled, and the hardness of the drill steel, are the deciding factors. Few drills are worked economically with air at a pressure above 100 pounds, on account of the rapidity with which the steel dulls, and the amount of vibration, particularly in hard rock. The frequent sharpening and changing of bits greatly increases the loss of time.

The accompanying table 1 shows the amount of air required to run from one to 50 Rand drills at an air pressure of 80 pounds at sea level. It is computed on a sliding scale, determined by experience, and gives the air required under usual working conditions. This means that with the increase in the number of drills used, less air is required per drill, or that there is a decrease in the percentage of the number that will be in simultaneous operation.

The amount of air that a compressor should furnish to run a certain number of drills at 80 pounds pressure may at once be determined from the table.

To find the air required for other pressure than 80 pounds multiply the amount given in the table by the following factors:

For 60 pounds by .789. For 70 pounds by .894. For 90 pounds by 1.105. For 100 pounds by 1.211.

The quantity determined, however, is the free air that a compressor should *deliver* compressed, and not its displacement capacity.

The figures given do not take into consideration the loss of pressure that the air sustains in its transmission from the compressor to the drills, due to friction and leakage in the pipes. In a properly constructed line, however, these losses do not amount to a great deal, and air is carried 5,000 to 10,000 feet with a loss of only 3 to 5 pounds in pressure.

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* Written for *Mines and Minerals*, by F. M. Hitchcock, M. E.

TABLE 1—*Air Required to Operate Rand Rock Drills at Sea Level, With Air at 80 Pounds Pressure Per Square Inch.*

Name of Drill	Kid	No.1	No.2	No.3	No. 3¼	No.4	No.5	No.7
Diameter of Cylinder, in Inches	1⅞	2¼	2¾	3⅛	3¼	3⅝	4½	5½
No. of Drills								
1	44	67	81	120	130	141	166	194
2	77	117	142	211	228	247	292	340
3	114	173	210	310	336	364	428	503
4	150	228	275	408	442	478	564	659
5	183	279	337	500	542	587	692	810
6	216	329	397	588	638	692	814	952
7	246	375	454	673	728	790	928	1,085
8	275	418	507	750	813	882	1,040	1,212
9	301	458	554	820	890	964	1,135	1,327
10	324	494	597	884	957	1,040	1,222	1,430
12	376	573	692	1,025	1.110	1,205	1,418	1,658
15	452	688	830	1,230	1,334	1,446	1.705	1,990
20	602	915	1.105	1,640	1,775	1,925	2.263	2,650
25	748	1,140	1,378	2,043	2,218	2,400	2,820	3,300
30	898	1,368	1,655	2,455	2,658	2,890	3,380	3,960
40	1,195	1,820	2,220	3,260	3,535	3,830	4,520	5,270
50	1,495	2,275	2,750	4,060	4,420	4,790	5.640	6,600

As the air decreases in density with the height above sea level, more free air must be compressed at altitudes than at sea level to give equivalent results.

Having noted in Table 1 the amount of air required to run a certain number of drills at 80 pounds pressure sea level, multiplying that amount by the factors in Table 2 will give the amount which is equivalent in effect at various altitudes, either at 80 pounds, or at 60, 70, 90 or 100 pounds pressure.

For an example, assume that we wish to run six No. 3 drills at 10,000 feet altitude, and at 90 pounds pressure. From Table 1 we see that they require 588 cubic feet of free air at sea level when running with air at 80 pounds pressure. From Table 2 we find the factor for the conditions given to be 1.542; hence, the amount of air required is 588×1.542=906 cubic feet.

TABLE 2—*Factors for Altitudes*

Altitude in Feet Above Sea Level	Atmospheric Pressure Pounds Per Square Inch	Factors				
		Air Pressure at Drill				
		60 Lbs.	70 Lbs.	80 Lbs.	90 Lbs.	100 Lbs.
Sea Level	14.75	.789	.891	1.000	1.105	1.211
1,000	14.20	.814	.923	1.033	1.142	1.252
2,000	13.67	.839	.952	1.066	1.179	1.293
3,000	13.16	.865	.983	1.102	1.220	1.338
4,000	12.67	.893	1.016	1.139	1.261	1.383
5,000	12.20	.922	1.019	1.176	1.303	1.431
6,000	11.73	.952	1.085	1.218	1.350	1.482
7,000	11.30	.982	1.119	1.257	1.395	1.534
8,000	10.87	1.015	1.157	1.300	1.443	1.586
9,000	10.46	1.049	1.198	1.347	1.491	1.642
10,000	10.07	1.083	1.236	1.390	1.542	1.695
11,000	9.70	1.119	1.279	1.439	1.599	1.760
12,000	9.34	1.157	1.322	1.488	1.656	1.824
13,000	8.98	1.197	1.370	1.543	1.716	1.889
14,000	8.65	1.236	1.415	1.594	1.775	1.956
15,000	8.32	1.279	1.465	1.652	1.810	2.028

Notes.

POSTMASTER-GENERAL CORTELYOU has decided to endorse recommendations for the extension of the pneumatic mail-tube service in Brooklyn.

ALFRED E. SHARPE, a fourteen-year-old boy of Iowa Falls, Iowa, has just completed an engine which may be run by either steam or compressed air.

THE Ohio Compressed Air House-cleaning Co., of Columbus, has been formed with the following incorporators: J. N. Koerner, E. J. Burkett, Walter L. Lillie, John L. Trauger and F. M. Leonard.

As a rule coal cutters of the compressed air puncher-type are more effective than electric cutters in low coal workings containing clay spots, which are much faulted. Rotary coal cutters are best suited to thick seams of clean coal.—*Engineering and Mining Journal.*

LORD MASHAM (Samuel Cunliffe-Lister), the patentee of many inventions, including a compressed air brake for railroads and a wool combing machine, died February 2, at Swinton Abbey, Masham, County of York, England. He was born in 1815 and was created a baron in 1891.

In a shop where the sand blast is now being used for cleaning crown bars and crown sheets, it formerly took a 17½-cent man 10 hours to clean a dozen bars —$1.75 for the lot. With the sand blast, a bar is cleaned in 20 or 30 minutes, or about half the time it took using the old way.—*Boiler Maker.*

Compressed air is sometimes used as a temporary relief in rooms in coal mines when the fan currents are insufficient. It is not an advisable proceeding, and is evidence of bad management. Every coal mine should have a fan capacity ample for all calls made upon it.—*Engineering and Mining Journal.*

Power may often be transmitted from the surface to the face of the workings in a coal mine by compressed air better than any other means. The chief disadvantages of the compressed-air system are, danger of dislocation of the pipe lines through fall of roof, and less flexibility when applied to underground haulage than the electric system.—*Engineering and Mining Journal.*

The Westinghouse Machine Company has opened a Philadelphia sales office in room 1,003, North American building. The establishment of this office was necessitated by the rapidly expanding business in this territory, particularly in gas engines and Westinghouse-Parsons steam turbines, and is in line with the progressive policy of the company to establish headquarters in all large industrial cities.

The term "capacity," when applied to an air compressor, is often misunderstood. It relates to the piston displacement in the large low-pressure cylinder of the compressor; it does not refer to the amount of compressed air the machine will deliver. The same machine when working under different pressures, or at different elevations above sea level, has the same capacity; but delivers different quantities of compressed air per unit of power.—*Engineering and Mining Journal.*

A high-altitude air compressor is designed to compress the lighter air in high altitudes to the same gauge pressure that another machine produces when working at sea level. At any appreciable altitude above sea level a larger number of compressions are required to produce the same sea-level gauge pressure. This is arranged by increasing the area of the air cylinder in the high-altitude compressor, and the valves are set so as to effect an earlier cut-off.—*Engineering and Mining Journal.*

An engineering and machinery exhibition will be held in London, England, from September 15 to October 17, 1906, under the presidency of Sir Wm. H. White, K. C. B., LL. D., F. R. S., and a distinguished patronage, including the foremost English scientists; the past presidents, presidents and vice-presidents of all the engineering institutions, the consuls of foreign countries, etc. While this exhibition has been held annually for some time, it has been on a much smaller scale than is planned for this year's.

There will be a full and generously illustrated description of the "New New York Custom-house" in the March *Century* by Mr. Charles de Kay. The fine new structure now nearing completion stands on Bowling Green, Whitehall Street and Battery Park, seven stories from street to roof, with two stories below the street. Convenient approaches, elevators, sunlight, electricity and ventilation will be conspicuous features of the new Custom-house as well as notable architecture and sculpture.

Gasoline air-compressors may often be employed advantageously in work that does not warrant the installation of a steam plant. A 3¼-inch drill will require about 12 horse-power, or 12 pints (1.5 gallons) of gasoline, which, at price of 15 cents per gallon, would make the operation for eight hours come to $1.20, reckoning that the drill is run two-thirds time. There may be also saving in attendance, as compared with a small steam plant. Gasoline air-compressors have been successfully employed in mining work.—*Engineering and Mining Journal*

The Cyclone Drill Co., Orrville, O., has been incorporated January 22, with a capital of $100,000, buying out the assets, including machinery, merchandise, patents, etc., of the Cyclone Drilling Machinery Co. and the Preslar-Crawley Mfg. Co. The new company will make drills of all types and also a combination drill embodying the hollow rod, cable and core drills. The directors of the company are: B. S. Cope, president; Chris. Smith, vice-president; Wm. H. Tschantz, treasurer; Wm. M. Knoppes, secretary, and Walter A. Knight.

PNEUMATIC tools have recently received an unexpected but deserved mark of approval by the agreement of the Workmen's Society with the Federated Shipbuilding & Engineering Employers of England and Scotland, to encourage the use of these appliances and to allow a substantial reduction in rates of pay for work done by their aid. Hereafter men using pneumatic tools will have their pay reduced 40 per cent. on shell plating and 35 per cent. on interior work generally. Such a concession would manifestly not be made unless the workmen were certain by experience that it was just to both hand and pneumatic work.—*Engineers' Record.*

A MACHINE for the manufacture of liquid air, the third to be installed in American colleges, is now a part of the equipment in the department of physics at the University of Minnesota. The machine is being used for experiments in radio-activity.

Liquid air can be manufactured in half an hour with the machine. The process is the usual one. After being freed of impurities the air is passed through a compressor such as is used on torpedo-boats for firing torpedoes. It is then passed through potassium hydroxide to condense the gases. After liquefying and expansion processes are completed the air is passed through tubes and collected.

A CORRESPONDENT of the "Wandsworth Borough News" has just brought to notice some interesting trials which took place nearly sixty years ago with a compressed air motor-car constructed in accordance with the patent of Baron Anthony Bernard Von Rathen, bearing date 2d November, 1847 (No. 11932). The machine was built at the workshops of that ill-fated institution, the Putney College of Civil Engineering, and a public trial of the car took place on the road between the college and Wandsworth on the 9th August, 1849, and again on the 11th of the same month. The car attained a speed of eight miles per hour on the first occasion and twelve miles at the second trial. The inventor seems to have displayed much ingenuity in the details of his machine, and it is somewhat surprising that nothing more was heard of it.—*Motor Car Journal* (Eng.).

FREDERICK T. TOWNE, superintendent of the Yale & Towne Mfg. Co.'s plant at Stamford, Conn., and son of Henry R. Towne, president of the company, died early on the morning of Sunday, February 4th.

Although only 34 years of age, Mr. Towne had made a name for himself in the industrial world. He was a member of the administrative council of the National Founders' Association from February, 1900, until November, 1903, during the last year of which time he served as president, although he was one of its youngest members. He was exceedingly active in its behalf and had much to do with formulating its policies.

Mr. Towne was a graduate of Tufts College. After completing his course there he entered the employ of the Yale & Towne Mfg. Co., speedily working himself up to the superintendency of its plants at Stamford and Branford, Conn., with 3,000 men in his control. It was his ambition to make the Stamford plant a model one, especially in the relations of employer to employes. He was a member of the American Society of Mechanical Engineers.

RIDGELY & JOHNSON Tool Company, of Illinois, control a patent recently granted to Henry H. Vaughan, of Cleveland, Ohio, on an improvement in pneumatic hoists.

The invention relates in general to fluid-pressure-operated lifted apparatus, and more particularly to pneumatic hoists. In a fluid-pressure-operated mechanism in which a pull or push is exerted by fluid-pressure medium, it is desirable that the mechanism should be retained in position to maintain the push or pull after the fluid pressure has been disconnected from the motor cylinder, thereby preventing condensation of steam or from leakage of compressed air. It is also desirable that the mechanism should be retained in position to maintain the push or pull until the load has either been removed or has been lifted by the re-admission of fluid pressure to the motor cylinder. The invention consists in a motor cylinder, a piston fitting within the cylinder, automatic means for retaining the piston in any position to which it may be moved by fluid pressure, and means for releasing the retaining means only when the load is no longer sustained thereby.—*The Manufacturer.*

An interesting feature of mining in the Cripple Creek district, and an item which is as closely watched by the operator as any other, is the cost of making air per drill shift, upon which largely depends the possibilities of economical operation. The wide range in this one respect is shown by the fact that in some instances the cost is as high as $3.00 per drill shift, while in others the same results are obtained at a cost of 53 cents. This great difference is due to the class of machinery used and the care and intelligence with which it is operated. Of the different records obtained from mine operators the following seems to show the greatest economy.

Mr. John Sharp, the well known lessee who is operating the Morning Glory of the Work, and the Colorado Boss of the Cripple Creek Consolidated Company, furnished data covering a period from September 20, 1904, to January 17, 1905, during which time 1,367 drill shifts were operated. As shown by his books during that time the coal bills amounted to $1,183.17. The greatest number of shifts worked in one month was in October, when 492 were employed.

The rock hoisted amounted to 7,500 tons during the months of October, November and December, and the coal bills for hoisting amounted to $450.00, leaving the total coal bill for running the air compressor $733.17, or 53.7 cents per drill shift.—*Mining Reporter.*

An interesting example of the general utility and adaptability of the Westinghouse air brake pump was given in connection with the raising of the lake steamer "Corey" exclusively by the use of twenty of these pumps. The "Corey" went aground on the shores of Gull Island, Lake Superior, during the severe gale of November 28 last. On the first of December, men and pumps were sent by two of the prominent northern railroads to prosecute the work of raising this vessel.

Ten 11-inch pumps and ten 9½-inch pumps were distributed along the deck of the steamer and arranged to force air into thirteen of the air-tight compartments in the vessel. This work was commenced on the second of December, and while the air was forced into the compartments by the pumps, the leaks were repaired by boilermakers as fast as they were discovered, either by being patched or by the use of cement. To accomplish this preliminary work of stopping all leaks required until December 9, about 3 P. M. At this time all of the pumps were set to work forcing air into the compartments in order to displace the water and raise the vessel. On the following morning at 7:30 A. M., it was found that the boat had been raised four feet and sufficient water removed by the compressed air to allow the steamer "Houghton" to easily pull the "Corey" from the shore into deep water. In raising this vessel it is estimated that from 3 P. M. on December 9 until 7:30 A. M. December 10 about 6,000 tons of water were removed by the use of these twenty pumps.

A new device has been put on the market by A. E. Hoermann, 261 Broadway, New York City, dealer in pneumatic and other machinery, which promises to have a good field.

The tool is supposed to be used in connection with an ordinary air or electric drill and to perform the work of screwing up, tightening and also unscrewing nuts.

Without doubt the largest field for this tool will be the railroad market. On some of the wooden freight cars, for instance, there are as many as 600 nuts of one kind, and needless to say the time consumed in tightening these by hand with a wrench is considerable.

The idea of using a tool of this kind is not a new one, but so far no satisfactory one has been placed on the market. Tests have been made by using solid chucks in drills, but the sudden jar caused at the moment the nut was drawn up on the surface soon put the drill out of commission.

The tool, built according to A. E. Hoermann's ideas, has an adjustable friction arrangement, which enables the operator to regulate the tension for the largest nut to be tightened.

The nuts to be tightened are placed on the bolts with about one and one-half turn, the tool will run them up to the surface and tighten them, then the friction arrangement will take up the jar and allow the drill to continue rotating while the wrench chuck itself remains stationary.

This tool has been thoroughly tested at the shops of the Central Railroad of New Jersey, at Elizabethport, and found to work remarkably well. It has been found, however, that a three-quarter-inch nut is the maximum capacity, not of the tool itself, but of the drill, as the largest drill is not strong enough to develop power to tighten a one-inch nut sufficiently tight.

AN article in *The Railway and Engineering Review* gives the following description of the piping system used in the Sedalia shops of the Missouri Pacific Railway:

"The compressed air is carried in three independent lines from the power house under ground to the various buildings, and the freight car repair yard. The pipe used for this purpose is Universal cast-iron pipe, manufactured by the Central Foundry Co., of New York. This pipe has special machined ends, with lugs cast at the ends so that the pipe may be laid in sections and bolted together. The pipe is laid in the ground with no further protection than a coat of coal tar. The line for the freight car repair yard leaves the power house at the west end and extends in a straight line about 1,700 feet west. A branch line leaving the main runs to the store house for the operation of air hoists; another line supplies the freight car repair shed and the scrap platform, and at 200 feet intervals branch lines are taken from the main and run north across all the tracks of the freight car repair yard. The pipe of both main and branches is cast with bosses at 3 feet intervals, so that the line may be drilled and tapped, and a riser brought to the surface of the ground at any one of these bosses. At the end of each of the branch lines is a cast-iron drip-pot, provided with a three-quarter inch blow-out pipe and control valve at the surface of the ground. The line is pitched to drain to the drip-pot and a cast-iron roadway box with a cover plate bearing the inscription "Drip Pot" marks the location of each one of the 19 bleeders on the underground air piping. In addition to these drip-pots, which have a capacity of 15 or 20 gallons each, there are five steel reservoirs or pressure accumulators, which still further collect condensation and provide reserve capacity at points of greatest demand for air."

AT the close of 1904 there were 156,456,370 feet or 29,632 miles of mains for the transportation of natural gas in the United States, which varied from 2 to 36 inches in diameter. The greater portion of the pipe in use is 8 and 10 inches in diameter. The line pressure on the smaller pipe up to 10 inches runs as high as 400 pounds; for 20 inches diameter the pressure is usually less than 300 pounds to the square inch. Originally the gas pressure in the wells was sufficient to transport large quantities in ordinary-sized pipes to points of consumption many miles distant. In many instances during recent years the gradual falling off of the natural pressure has made it necessary to instal powerful pumping or compressing machinery.

By far the most economical results have been secured by large gas-engine compressors, in which natural gas is exploded instead of steam being used, and in which 9 cubic feet have developed 1 horse-power per hour, while working at about 1,500 horse-power capacity. Thirty cubic feet of gas have been compressed from 0 to 270 pounds pressure to the square inch by the consumption of 1 cubic foot of natural gas, whereas double that amount of gas is consumed under boilers supplying double-expansion condensing steam engines to do the same work.

In recent years there has developed a general extension of many of the large lines, supplying central western Pennsylvania and northeastern Ohio, into the deep and prolific fields of southwestern Pennsylvania and western West Virginia, which are now operated in a most economical way, enforced by the dearly learned lessons of the reckless exhaustion of the original fields of Pennsylvania, Ohio and Indiana. Much larger lines have been recently constructed, and the increase in diameter has added largely to their capacity and has increased the quantity of gas delivered at points of consumption.—*Engineering and Mining Journal.*

A CORRESPONDENT of the *Milwaukee Sentinel* writes from Ironwood, Mich., as follows:

"An interesting sight at Corrigan, McKinney & Co.'s Great Western mine at Crystal Falls, Menominee range, is a combination pump operated by compressed air. The history of this unique device dates back several years, when a collapse of the surface ground, caused by the caving system of mining, carried down stopes and threatened the life of the shaft. A considerable portion of the cave, approaching 200 feet in depth, was thereupon filled with sand and the stability of the shaft was restored. It was necessary to instal pumps in order to prevent the flooding of the mine, but instead of pumping the water direct by steam, a method which on account of the sand would be destructive to the ordinary type of pumping machinery, a small air compressing plant and vacuum pump were put in and two cylindrical tanks, each of a capacity of 2,000 gallons, were installed in the bottom of the pit. Each tank is equipped with a water inlet, discharge pipe, and check valve at the bottom, and a compressed air and vacuum pipe at the top. The tanks, connected, occupy space in a reservoir which is the receiving vat for all the surface water.

"While the water is forced into one tank by compressed air, the same movement of the pump drives the air out of the other tank, creating a perfect vacuum and forcing the water into the pipe which conveys it to the top of the pit and into the sluiceway by which it is carried out of range of the mine. When the tank is emptied of water, the air in it, which is under compression, is automatically withdrawn and taken back into the compressor, losing only a part of its pressure in the process and adding materially to the economy of the device. The two tanks operate in balance, one filling while the other is discharging, and thus a continuous stream of water is maintained. The only parts of the device to which the sand in the water can exert a destructive force is on the check valves, saving greatly in wear and tear."

THE American Institute of Mining Engineers, which for the two days preceding has been in annual session at Bethlehem, Pa., was on Saturday, February 24th, entertained by the Ingersoll-Rand Company at its works at Phillipsburg, N. J.

A special train brought the visiting party, about 165 in number, from Bethlehem direct to the shop grounds. The guests were received by President W. L. Saunders of the company, assisted by members of the sales and engineering departments both from Phillipsburg and New York. The party was at once photographed on the steps of the office building, and each guest was presented with a leaflet showing a plan of the works.

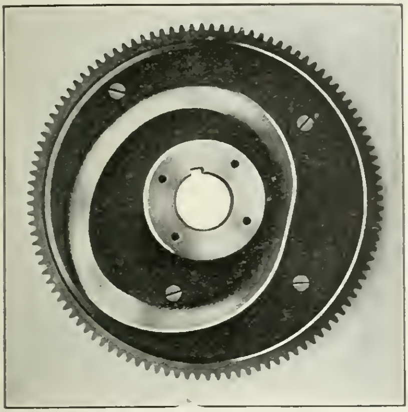
The guests, divided into parties, were piloted by representatives of the company over the specified route through the shops, inspecting the many classes of machinery built there, both in construction and in operation. After a morning spent in this manner, the visitors were conducted to the dining room on the third floor of the office building, where a luncheon was served to about 195 guests and company representatives.

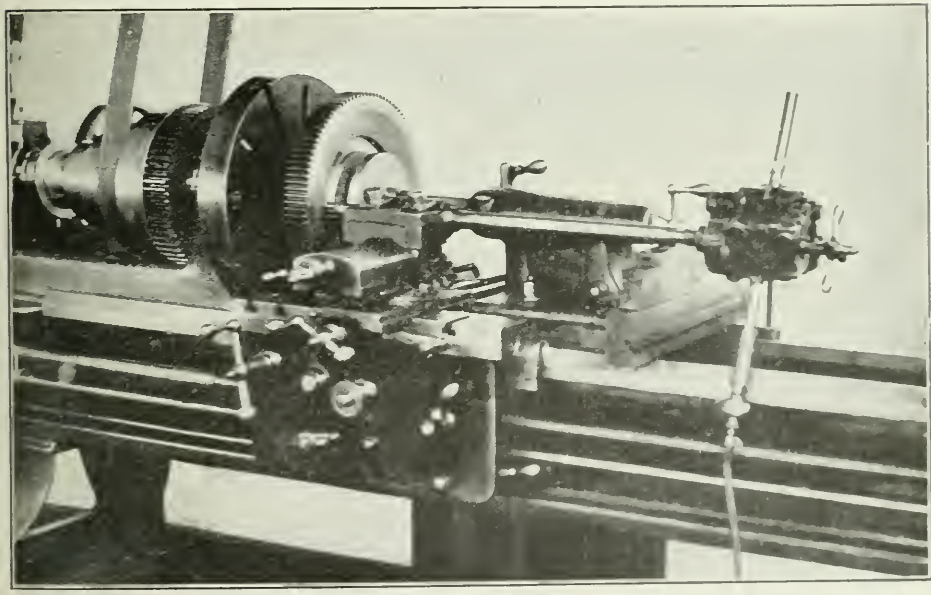
After an hour of fellowship and good cheer, a second photograph was taken and the company was called to order by Mr. De Saules, acting chairman of the entertainment committee. After a few happy remarks of appreciation of the day's entertainment, the chairman called upon President Saunders of the Ingersoll-Rand Company, who responded, calling attention, among other things, to the fact that the Institute was not up-to-date in that it still clung to the hand hammers on its emblematic seal, which should properly be replaced by a machine drill as more typical of modern engineering progress.

Mr. Jasper Rand, vice-president of the company, was then called upon and dwelt in his remarks upon the close and intimate relations in the new company which had taken the place of the keen rivalry between the former Ingersoll and Rand Companies. The next speaker was Mr. Edmund C. Pechin, one of the charter members of the Institute, who gave some historical reminiscences. He was followed by Dr. Raymond, secretary of the Institute, since its foundation. The informal program closed with a song by Prof. Franklin, of Lehigh University, an Institute member, which told of the intimate relations of "Sandy and his Mule" in the days before machinery was introduced in the coal mine. The party then adjourned, returning by their special train.

A number of ladies, guests of the Institute, were in attendance, lending to the occasion the charm of their presence.

THE accompanying illustrations show an irregular box cam and a novel method introduced for cutting it. It will be observed that at one point the groove is located very close to the centre of the gear, while it runs close to the rim at another point; hence it could not be cut with a single tool, it being absolutely necessary that the groove of the cam be parallel.





Not having a machine particularly adapted to the work an emergency method was devised consisting of a block mounted on slide of engine lathe in which a milling cutter was free to revolve. A master cam was attached to mandrel with gear in proper relation to it; as the lathe revolved slowly (slide rest having previously been disconnected from cross-feed screw) the milling cutter arbor was kept in contact with master cam by means of weight fastened to end of cross-feed slide. The cutter arbor in contact with master cam was the same diameter as the milling cutter used; this insured an absolutely parallel slot. A "Little Giant" air drill was used for driving the cutter. The arrangement proved very satisfactory as the speed could be controlled to a nicety; it made the fixture at minimum cost; no cumbersome belts or other complicated mechanism being necessary, and the set-up required no more time than an ordinary chucking job. We are indebted to Mr. Henry J. Kimman, superintendent of the Cleveland plant of the Chicago Pneumatic Tool Company, for the illustrations and explanation covering the work.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

To the Editor of COMPRESSED AIR:

We have a problem in compressed air pumping to be solved which we herewith submit to you.

We have a well 720 feet deep cased with steel pipe 7⅝ inches in diameter to 470 feet; there is an intermission of 20 feet in which there is no casing, then 220 feet of 5⅝-inch casing. At 470 feet natural gas and oil were obtained. At 720 feet natural gas and salt water were obtained. The water rises to the top of the well, carrying with it oil and gas, which bubbies over the top of the well presumably two to four gallons per minute. Many attempts within the past three months have been made to pump the well dry by means of a deep well pump operated by compressed air, the air compressor giving 70 cubic feet at 80 pounds pressure, and the results achieved have been discouraging. Our purpose is to pump the well dry so that we may secure the gas which comes in about 700 to 710 feet which is just above the salt water.

Yours very truly,
BRYAN OBEAR.

Provided the well yields more water than the deep well pump can handle, the air lift system is the only method to employ promising any possibility of lowering the water to a point where the water seal will be broken, and the gas under a certain amount of pressure, liberated to escape with the water pumped. The question of just how far the water level in the well will have to be lowered (the static head reduced) in order to release the gas being unknown, depending upon the gas pressure, the necessary capacity of the compressor and pressure of air cannot be determined at the time.

Considering the air lift system, it will not be practicable to pump the water down to the very bottom of the well—"to pump it dry"—as you state, because this method of pumping depends for its proper operation upon a certain amount of submergence for the piping, or, in other words, the air and discharge pipe must be under water for a certain proportion of their total length in order to give satisfactory results.

We believe, however, using the air lift system, you can lower the water level and reduce the water pressure now holding the gas to such an extent that by pumping into a tank fitted with baffles, or arranged in such a way as to readily separate the gas from the water, that the desired results can be obtained.

It is hardly possible that this can be done with a compressor the size mentioned, but it will be possible to get a line on the requirements by fitting up and testing with this machine, and it will cost but very little to make such a trial.—EDITOR.

To the Editor of COMPRESSED AIR:

With reference to the power for use at the well which is intended to be pumped, I beg to say that the compressor will give about 70 cubic feet of free air per minute at 80 pounds pressure.

The air compressor is a hydraulic compressor, being driven by a steam pump to furnish an artificial head of water which is alternately driven into tanks compressing the air above it at the rate of about a revolution every 45 seconds. It is possible to secure 80 feet per minute at a 100 pounds pressure. I enclose you a small blue print of the invention which will give an idea of my hydraulic air compressor.

With reference to the depth which we have been able to pump the well, beg to say that the water has been lowered in it by means of a deep well pump to about 550 feet. At this point the pump stopped working and refused to take the air. We have just taken the pump out and find that the valves were glotted to such an extent with oil that they did not perform their proper functions. During the pumping of the well there was no accurate test of efficiency made, but we estimate that we pumped one gallon of water to two cubic feet of free air. At the next attempt to pump the well I shall pump the water into a tank and measure it accurately and keep a record of the air compressor.

Yours very truly,
BRYAN OBEAR.

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808,623. CARRIER FOR PNEUMATIC TUBES. Birney C. Batcheller, Philadelphia, Pa., assignor to The Pearsall Pneumatic Tube and Power Company, New York, N. Y., a Corporation of New York. Filed Mar. 21, 1905. Serial No. 251,210.

808,638. FLOATING CAISSON FOR REPAIRING FLOATING DRY-DOCK BOTTOMS. Andrew C. Cunningham, Annapolis, Md. Filed Mar. 10, 1905. Serial No. 249,398.

An under-water-floating caisson for repairing the bottoms of floating dry-docks, the same comprising an open-topped working chamber having a bottom and closed on all sides, said chamber being adapted to be entirely submerged and floated under the dock; and provided with means for exhausting the water therefrom, and having a shaft extending above water to permit workmen to enter the chamber after it is in place.

808,680. AIR-GUN. David F. Polley, Plymouth, Mich., assignor to Markham Air Rifle Company, Plymouth, Mich. Filed Dec. 19, 1904. Serial No. 237,572.

808,703. LOAD-BRAKE APPARATUS. Walter V. Turner, Wilkinsburg, Pa., assignor to Westinghouse Air Brake Company, Wilmerding, Pa., a Corporation of Pennsylvania. Filed Apr. 1, 1904. Serial No. 201,167.

808,711. COMBINED AIR-BRAKE-SETTING DEVICE AND ALARM. Robert E. Adreon and Francis M. Stambaugh, St. Louis, Mo.; said Stambough assignor to said Adreon. Filed Apr. 14, 1905. Serial No. 255,664.

808,716. BRAKE SYSTEM. Charles E. Barry, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Aug. 13, 1903. Serial No. 169,319.

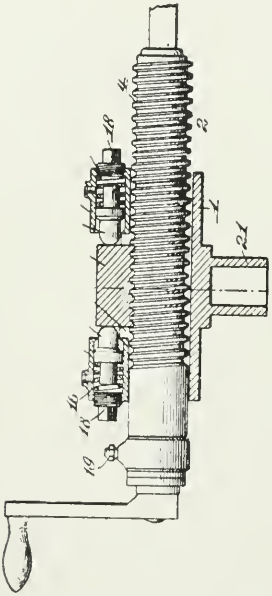
808,728. FLOATING CAISSON. Andrew C. Cunningham, Washington, D. C. Filed Sept. 20, 1905. Serial No. 279,347.

An under-water floating caisson for the purposes described, comprising an open-topped working chamber having a bottom and closed on all sides, said chamber being adapted to be entirely submerged and to be floated under the structure to be repaired, means for gaining access to the chamber from above the water after it is in place and for exhausting the water therefrom, and floats exterior to the chamber for suspending or maintaining it at the desired depth of submergence while being moved into place.

808,768. COMBINED DOOR, LOCK, AND INDICATOR FOR CARRIERS USED IN PNEUMATIC TUBES. Patrick J. Madigan, Chicago, Ill. Filed Feb. 25, 1905. Serial No. 247,309.

808,811. AUTOMATIC PRESSURE-RETAINER. James W. Brown, Minneapolis, Minn. Filed Aug. 27, 1904. Serial No. 222,386.

808,837. ROCK AND COAL DRILL. Lester C. Hardsocg, Ottumwa, Iowa. Filed May 17, 1905. Serial No. 260,786.

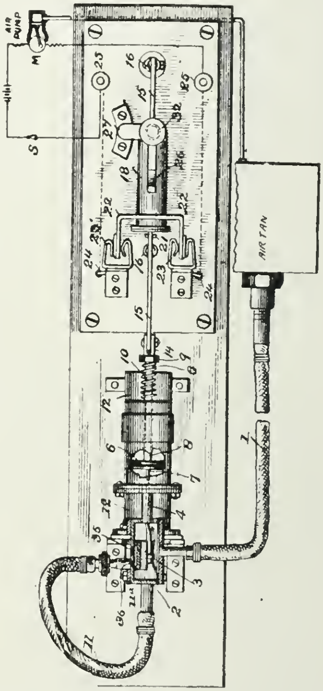


A housing, a hammer mounted therein and provided with exterior screw-threads, a slidably-mounted hinged block having screw-threaded engagement with said hammer, spring-pressed plungers located at opposite ends of said block for cushioning the movements of the same, means for adjusting the tension of the springs of said plungers, and means for turning said hammer.

808,974. PROTECTOR FOR PNEUMATIC TIRES. Henri David, Paris, France. Filed Jan. 20, 1904. Serial No. 189,856.

808,903. AUTOPNEUMATIC MUSICAL INSTRUMENT. Walter Crippen, New York, N. Y., assignor to Wilcox & White Company, Meriden, Conn., a Corporation of Connecticut. Filed June 5, 1905. Serial No. 263,710.

809,083. AUTOMATIC ELECTRICAL CONTROLLER FOR AIR-COMPRESSORS. Fred D. Ackerman, Kendallville, Ind. Filed May 17, 1905. Serial No. 260,865.



The improved automatic controller for the purpose specified, comprising a valve-chest and valve, an air-cylinder and a slidable piston contained therein and connected with said valve, a spring for opposing the movement of the piston in one direction, a second air-cylinder having a spring-pressed piston, an air conductor connecting such second cylinder with the valve-chest, a slidable bar connected with the last-named piston, a casing supplied to and slidable on said bar, a spring contained within the said casing and applying pressure between it and the bar, an electrical switch one member of which is connected with the casing, and spring locking and release mechanism connected with the casing for holding it normally immovable and the switch normally closed until a certain predetermined air-pressure is accumulated.

809,206. MINING-MACHINE. Daniel R. Murphy, Scenery Hill, Pa., assignor to Joseph A. Jeffrey. Columbus, Ohio. Filed Feb. 20, 1904. Serial No. 194,586.

The combination of a motor platform or carrier, a cutter-frame having a central thrust-rail adjustable relatively to the motor-carrier and having its rear end loosely braced, and a connecting and bracing bar projecting forward from the motor-carrier and adjustably clamped to the said centre rail of the cutter-carriage, substantially as set forth.

810,061. PNEUMATIC-CUSHION WHEEL. Charles A. Lee, Kansas City, Kans., assignor of one-half to Albert J. Holzmark, Kansas City, Kans. Filed June 28, 1905. Serial No. 267,471.

810,298. AIR-LOCK FOR CAISSONS. William McIlvrid, Jersey City, N. J., assignor to The Cockburn Barrow and Machine Company, Jersey City, N. J., a Corporation of New Jersey. Filed June 22, 1905. Serial No. 266,488.

A casing having a stationary top portion extending partially over the upper end thereof, said casing having an opening in its side extending lengthwise thereof to permit of removing and replacing the bucket, and means for simultaneously closing said opening and that part of the top of the casing not covered by said stationary portion.

810,316. EMERGENCY RAIL-BRAKE. Powell O. Adams, Cameron, Tex. Filed July 6, 1903. Serial No. 164,194.

809,409. PNEUMATIC TIRE. Pardon W. Tillinghast, Edgewood, R. I. Filed Mar. 5, 1903. Serial No. 146,396.

809,530. PNEUMATIC-TIRE COVER. William A. Sankey, Sutton, England, assignor to Frank Reddaway, Manchester, England. Filed Jan. 24, 1905. Serial No. 242,544.

809,633. SUBMARINE MINING. Edgar F. Scheibe, New York, N. Y., assignor, by direct and mesne assignments, to Submarine Gold Mining Company, a Corporation of New York. Filed Mar. 1, 1905. Serial No. 247,904.

In combination a support arranged to rest on the bottom, and a caisson supported thereby and adapted to extend to the bottom to permit expulsion of the water therefrom within the area of the caisson.

809,707. PNEUMATIC TRAIN-CONTROL SYSTEM. John B. Linn, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Oct 16, 1902. Serial No. 127,461.

809,774. SYSTEM OF CONTROL. Frank E. Case, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed June 12, 1905. Serial No. 264,763.

809,908. SYSTEM OF CONTROL. Frank E. Case, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Oct. 1, 1904. Serial No. 226,755.

809,919. PNEUMATIC MOTOR. Lawrence U. Jobes, Cincinnati, Ohio. Filed Dec. 5, 1904 Serial No. 235,545.

The combination with a bellows, of a bellows-passage communicating therewith, a valve-passage leading from the bellows-passage to the exhaust-passage; an exhaust-passage communicating with the valve-passage by way of a port; a valve controlling said port; a pneumatic placed in said exhaust-passage operating said valve; a pneumatic passage leading from said pneumatic in the exhaust-passage to the outer air with a pneumatic-port at the outer end thereof; an air-passage communicating with said bellows, having an air-port at the outer end thereof, the pneumatic-port and air-port being controlled by a single slide-valve.

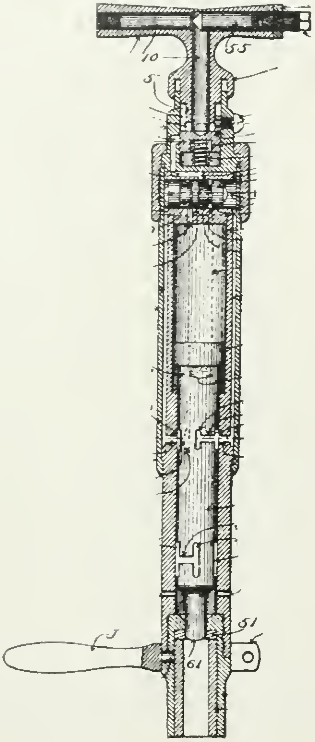
810,428. TUNNEL-SHIELD. Charles L. Parmelee, Orange, N. J., and Edward G. Williams, Washington, D. C. Filed Jan. 3, 1905. Serial No. 239,299.

810,450. APPARATUS FOR TREATING AIR. Frederick White, Boston, Mass., assignor to Regenerated Cold Air Company, Portland, Me., a Corporation of Maine. Filed Sept. 4, 1903. Renewed Nov. 11, 1905. Serial No. 286,790.

810,451. APPARATUS FOR TREATING AIR. Frederick White, South Boston, Mass., assignor to Regenerated Cold Air Company, Kittery, Me., a Corporation of Maine. Filed Aug. 8, 1904. Renewed Nov. 11, 1905. Serial No. 286,791.

810,514. FLUID-PRESSURE BRAKE. Walter V. Turner, Wilkinsburg, and John S. Custer, Pittsburg, Pa., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Apr. 27, 1904. Serial No. 205,116.

810,603. PNEUMATIC TOOL. William E. Badger, Quincy, Mass. Filed July 20, 1904. Serial No. 217,364.

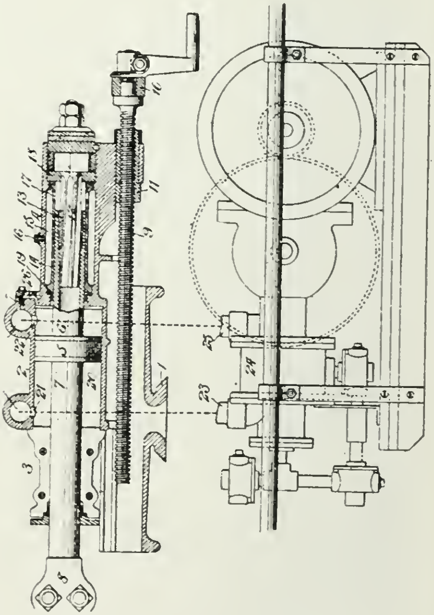


A pneumatic impact-tool, including a cylinder and piston, a valve-casing having a valve therein for controlling the movements of the piston, a head secured to said cylinder and held in fixed relation thereto and to said valve-casing, a handle or support upon which said head is rotatably mounted, said head having a passage for motive fluid which is alternately placed in communication with opposite ends of the cylinder, a passage in said handle which may be connected with a source of fluid-pressure supply and is adapted to be placed in communication with said passage in the head, and means to rotate said cylinder with relation to said handle and source of fluid-pressure supply.

810,609. ELECTROFLUID PRESSURE MECHANISM FOR OPERATING RAILROAD APPLIANCES. Walter J. Bell, Los Angeles, Cal., assignor of one-half to Leon F. Moss, Los Angeles, Cal. Filed Dec. 1, 1903. Serial No. 183,355.

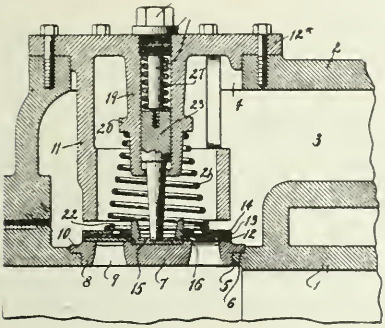
810,624. PRESSURE-CONTROLLING DEVICE FOR THE AIR SPRINGS OF PRINTING-PRESSES. Charles P. Cottrell, Westerly, R. I., assignor to C. B. Cottrell & Sons Company, New York, N. Y., a Corporation of New Jersey. Filed Apr. 4, 1905. Serial No. 253,787.

810,639. ROCK-DRILL. Arthur H. Gibson, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed June 9, 1905. Serial No. 264,433.



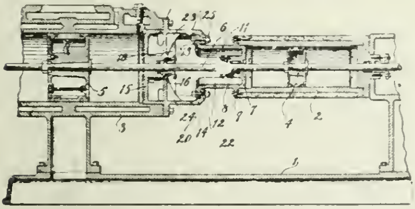
The combination with a rock-drill cylinder having a rear extension, of a piston having a hollow tail-rod extended into and entirely inclosed by said rear extension, a sleeve surrounding the tail-rod forming an annular chamber within the rear extension, a rifle-bar telescoping within the tail-rod and a port leading from the annular chamber to the air-space within the sleeve and tail-rod.

810,672. DISCHARGE-VALVE FOR FLUID-COMPRESSORS. William Prellwitz, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Apr. 1, 1905. Serial No. 253,247.



A valve-seat, a valve, its spring for yieldingly holding the valve closed, a removable valve-guide engaged with the seat and means for yieldingly holding the valve guide and seat in position.

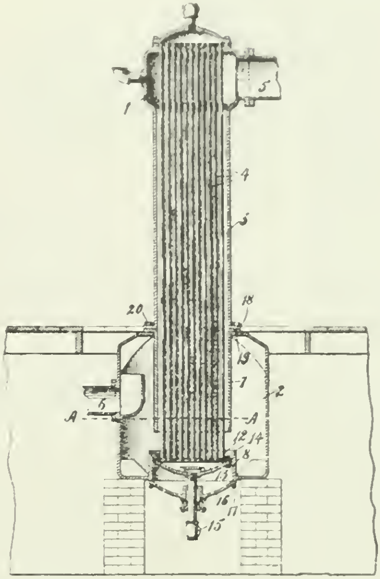
810,671. SEPARABLE HEAD-COUPLING. William Prellwitz, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Mar. 8, 1905. Serial No. 249,135.



A separable head-coupling for alined cylinders comprising two cylinder-heads having shanks removably secured together, one of the heads when released being arranged to permit its shank to telescope within the shank of the other head.

810,725. BELL-RINGER. Richard M. Crosby, Tacoma, Wash. Filed Aug. 2, 1905. Serial No. 272,298.

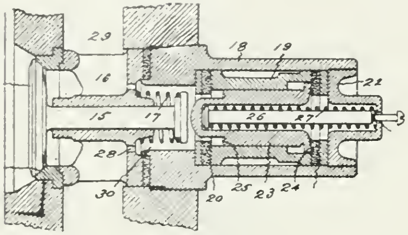
810,670. COOLER FOR COMPRESSORS. William Prellwitz, Easton, Pa., assignor to The Ingersoll Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Apr. 14, 1903. Serial No. 152,582.



A cooler for compressors comprising a stack of cooling-tubes, a casing therefor having an upper fluid-inlet head, a lower fluid-discharge head, and a connecting body portion extended into the interior of the fluid-discharge head about the portion of the stack of tubes extended therein and removably secured to the discharge-head whereby the air is confined to the stack of tubes within the discharge-chamber and the cooling-tubes may be removed from the discharge-head by a comparatively short upward movement of the body portion.

810,759. VALVE FOR COMPOUND AIR-COMPRESSORS. Ebenezer Hill, Norwalk, Conn. Filed Jan. 24, 1905. Serial No. 242,498.

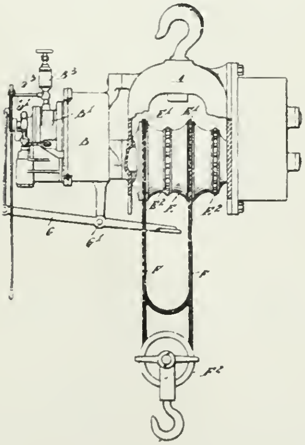
A valve for the intake-passage of an air-compressor having a valve-disk adapted to open and close the passage, a plunger movable toward and from the disk, said plunger having a surface at its inner end that is exposed to the air pressure in the intake-passage when the plunger is at inner limit, and a larger surface back from its inner end that is exposed to the air-pressure in the intake-passage when the plunger is moved from its inner limit, whereby the pressure against the smaller surface will tend to move the plunger away from the disk and pressure against the larger surface will tend to hold the plunger away from the disk, and a spring arranged to force the plunger against the air-pressure when the pressure drops below normal and cause the plunger to interfere with the ordinary action of the disk.



810,862. SAFETY COUPLING-SECTION FOR AIR-BRAKE PIPES. William J. Hofstatter, Toledo, Ohio. Filed Aug. 19, 1904. Serial No. 221,370.

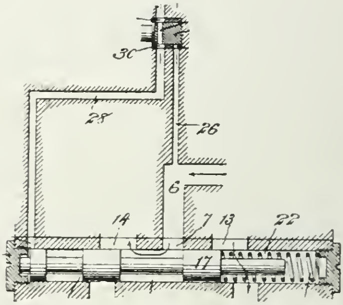
810,863. COUPLING-SECTION FOR TRAIN AIR-PIPES. William J. Hofstatter, Toledo, Ohio. Filed June 17, 1905. Serial No. 265,697.

810,884. PNEUMATIC HOIST. James L. Pilling, Bucyrus, Ohio, assignor to Pilling Air Engine Company, Detroit, Mich., a Corporation. Filed Dec. 27, 1904. Serial No. 238,536.



A hoisting mechanism, including the combination of a rotatable horizontal shaft, a plurality of sprockets thereon, a loop-chain having its two strands passing over two sprockets, a motor to rotate the shaft, a throttle-valve to control said motor, and means adapted to be actuated manually or by contact with another portion of the mechanism whereby said valve may be actuated.

810,890. REVERSING MECHANISM FOR ROTARY MOTORS. Albert H. Taylor, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed July 14, 1905. Serial No. 269,607.



A motor, means for supplying motive fluid thereto, a reversing-valve, passages leading from the motive-fluid supply and the opposite sides of the motor piston-chamber to the face of the valve, a port in the valve for alternately opening communication from the fluid-supply passage to the one or the other of the motor piston-supply passages, exhaust-ports opening to the face of the said valve and ports in the valve for alternately opening communication from the one or the other of the motor piston-supply passages to the one or the other of the said exhaust-passages, a spring for moving the reversing-valve in one direction and means for controlling the supply of motive fluid for moving the valve in the opposite direction.

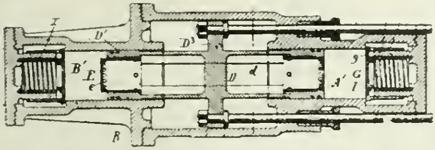
811,064. AIR-BRAKE. Edwin T. Hughes, Gladstone, Colo., assignor of one-fourth to Vincent J. O'Brien, one-fourth to Willis Z. Kinney, and one-fourth to James M. Rogers, Silverton, Colo. Filed Oct. 9, 1905. Serial No. 281,912.

811,109. PNEUMATIC TIRE. Friedrich Veith, Hochst-in-the-Odenwald, Germany. Filed Apr. 29, 1905. Serial No. 257,971.

811,110. APPARATUS FOR PUMPING LIQUID. George L. Waterhouse, New York, N. Y. Filed June 13, 1905. Serial No. 264,981.

An apparatus comprising a plurality of receptacles provided with liquid induction and eduction means, means for controlling the flow of steam to each receptacle to accord with the rise and fall of liquid therein, means for discharging heated fluid from the lower interior of one receptacle into the upper interior of another receptacle upon a charge of liquid therein before steam is admitted thereto, and means for causing condensation of steam in said receptacles after liquid has been discharged therefrom.

811,181. GAS-COMPRESSOR. Louis Sterne, London, England. Filed Aug. 18, 1904. Serial No. 221,279.



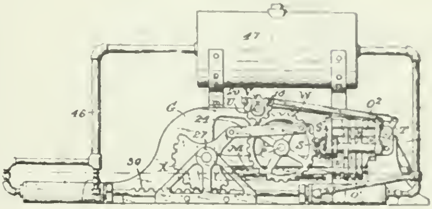
A double-acting gas-compressor, composed of two tandem single-acting single-stage compressor-cylinders, each having a delivery-valve at its outer end, a gas-tight casing of larger diameter connecting the adjacent inner ends of the cylinders, a return-gas inlet to the casing, two connected hollow trunk-pistons working in the respective cylinders, each such piston carrying a suction-valve and apertured to afford communication between the casing and the valve, radial arms on the pistons, and piston-rods connected to the arms and passing through lateral stuffing-boxes at one end of the casing, whereby the cylinders, pistons and piston-rods are kept at a moderate uniform low temperature.

811,296. PNEUMATIC SPRING FOR VEHICLES. Matthew M. Howland, Providence, R. I., assignor of one-half to William W. Dunnell, Providence, R. I. Filed May 11, 1905. Serial No. 259,969.

811,330. PRESSURE AND SUCTION DEVICE. Eugen Roth, Schoneberg, near Berlin, Germany. Filed May 6, 1904. Serial No. 206,759.

An air-tight chamber having an elastic flexible wall, and a series of devices conforming to and movable with said wall, to prevent disruption thereof; with levers contacting said devices, a reciprocity rod, and an operative connection between the rod and levers.

811,378. AIR-COMPRESSING ENGINE. Hobbs E. Clifford, Lafontaine, Ind. Filed Apr. 17, 1905. Serial No. 255,926.



An engine including a support having a chamber therein, a hollow cylindrical abutment secured fixedly at an end thereof to the support in communication with the chamber thereof and provided at the opposite end thereof with a valve-seat, a valve operative on the valve-seat and having an operating rod extending through the chamber of the support, a hollow cylinder movable on the abutment, a rotative shaft having a crank, operative connections between the hollow cylinder and the crank of the shaft, and connections between the rotative shaft and the operating-rod of the valve.

811,400. PNEUMATIC BELL RINGER. John Howe, St. Joseph, Mo. Filed May 6, 1904. Serial No. 206,772.

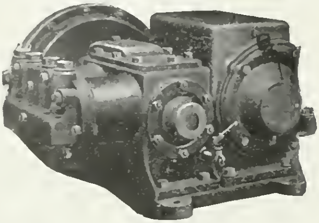
The combination of a bell-crank for an alarm-bell, a cylinder provided with inlet and exhaust ports in the wall at one side thereof, only, a reciprocating piston mounted therein and provided with inlet and exhaust passages arranged to be connected and disconnected alternately with the inlet and exhaust ports in the cylinder, means for keeping the reciprocating piston seated on the port side of the cylinder-wall, and means for connecting the reciprocating piston with the bell-crank.

811,507. AUTOMATIC AIR-BRAKE APPARATUS FOR AUTOMOBILES. Frederick Kalisch, St. Louis, Mo., assignor of one-eighth to Geo. D. Kluegel, St. Louis, Mo. Filed Mar. 24, 1905. Serial No. 251,903.

811,525. AIR-BRAKE. William L. Stuarwalt and William H. Cool, Bellefontaine, Ohio. Filed June 22, 1905. Serial No. 266,533.

811,532. PNEUMATIC STACKER. Henry J. Daws, Hopkins, Minn., assignor to Severin N. Sorensen, Minneapolis, Minn. Filed Feb. 6, 1904. Serial No. 192,293.

Westinghouse Air Compressors



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Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. XI. APRIL, 1906. NO. 2

Editorial Announcement.

Commencing with the May issue, COMPRESSED AIR will be published hereafter by The Kobbe Company, New York. The ever increasing uses to which compressed air is being put, and the important place it holds in hundreds of industries to-day have made it imperative that COMPRESSED AIR, for ten years the leading—in fact, the only—periodical devoted exclusively to this subject, be correspondingly enlarged and broadened to keep pace with the progress of pneumatics in general, for which it stands sponsor.

The form of the paper will be changed in that its size will be 7 by 10 inches, and there will be other radical improvements, so that COMPRESSED AIR, in outward form, will be on a level with the best printed and illustrated magazines now published.

Mr. W. L. Saunders will still remain as Editor-in-Chief. Mr. W. R. Hulbert, M. E., well fitted, both as a theoretical and practical engineer, will be managing editor.

Contributions and correspondence from those interested in the uses and development of compressed air for industrial purposes will be gladly received and made use of if acceptable, and requests for information will be given prompt and courteous attention.

To those of our readers who bind their copies of COMPRESSED AIR, we make the following suggestion: That they include among their copies for the year 1904-1905 the issues of March and April; these latter issues really belong to the year 1905-1906, but as COMPRESSED AIR appears in enlarged form with its issue of May, it might not be expedient to bind them with the larger copies.

The "Air Man's" Point of View.

It is a great mistake in the initial installation of a compressed air plant to provide only for the immediate needs of the establishment. It might be set down as a rule without exception that once air tools are used in a shop, the demand for their services will increase. Unless there is something radically wrong in the construction and operation, they will prove their ability as time and money savers. When it is demonstrated that the first equipment of tools will not supply the demands, additions are bound to come. As a result more air will be needed. If the compressor and the piping system were not originally designed to meet the increased needs it means a distinct loss which, with a little foresight, might have been avoided. An air compressor continually operated with an overload, cannot be economical. The best compressor will meet such demand for a time, but it is going to save money to put in a larger compressor rather than run one constantly above its rated capacity. An insufficient piping system means a reduction in the air pressure, with [illegible] sequent injury to the effectiveness of the tools in operation.

The day when the installation of a compressed air plant in the factory, machine shop or foundry was an experiment, has passed. If proper attention is given to the selection of the most suitable equipment and its proper installation, there need be no guess-work as to the increase in the demands for that form of power in the future and consequent increase in output of your plant.

In addition to the natural growth of the plant, experience has proven that as soon as the compressor has been installed the air can be used to advantage, and with economy, in a variety of ways which were not considered at first. While none of these may be important enough singly to have made the first installation of such a plant desirable, they are of sufficient importance to make it advantageous to supply the air needed, after once the installation is made. Such uses are likely to develop in the course of time, and failure to care for them will mean a loss of small but valuable economies.

It is a fact that too little attention is given to the installation of a compressed air equipment. When a manufacturer plans his factory, his power plant is a very important consideration. He looks into the subject deeply and considers the merits of engines, boilers and the like, with a view to meeting his own particular conditions. The same care should be taken in the selection of the air compressor, the arrangement of the piping system and the choice of the attendant pneumatic machinery. Too many shop men put the compressor away in a corner, connect it with a few hundred feet of pipe, and trust to willing but inexperienced hands to develop it into an economical part of the shop system. Compressors can be operated by men without experience, and it is by no means essential that a corps of practised operators with pneumatic tools be engaged in their shop. You cannot, however, expect economical results unless there is proper care for the compressor and the devices which utilize the compressed air.

This development of the use of compressed air has brought to the fore a class of skilled mechanics, who for the want of a better title, may be called "air men." Their experience and training has taught them to look after the various details of the compressed air plant. and to get the best out of it that is possible. Their point of view is an interesting one. We are publishing in this issue an article written by one of these men, who has had much experience in this field and whose ideas will be read with interest, not only by his fellow workers, but by the makers of compressed air machinery and the manufacturers who use its machinery.

The "Air Man's" Point of View.

BY THE "AIR MAN."

It may not be uninteresting to look at the pneumatic end of up-to-date manufacturing establishments from the point of view of the air-man, who is more or less in charge of air service and tools and is held responsible for almost every shortcoming; being in many cases the long-suffering victim of circumstances entirely beyond his control.

He is a kind of a buffer between the compressors and the workmen, gets the knocks on both sides; and if not of some capacity, great patience and inexhaustible interest in his work, is quite likely to be put down and out without recourse.

His duties in different establishments in the same line of business probably vary more than those of almost any other position, partly because the managers of the business have no special knowledge of air and its application, and no time to acquire the same, and partly because few men have had opportunities to perfect themselves so as to satisfactorily perform all duties that should be theirs.

The management may add the air-plant to their establishment because competitors have by its use attained results otherwise impossible.

Having decided to install a plant, they select one recommended by their friends, or used by their competitors, or the quickest, or the cheapest attainable; let their piper—who, very likely, never saw an air-plant—plan and install pipe lines for distribution and in a comparatively short time learn that instead of a dozen or so of tools, they could economically use fifty—not to mention the other uses, more or less legitimate, that are always being made of air wherever available—and that both compressor and pipe lines should be double or treble the capacity which was at first deemed ample.

Perhaps they do not at once appoint an air-man, but add the responsibility of running and caring for the compressors to the other duties of the engineer, who has already enough to look after without having to care for a kind of power in which he is totally inexperienced.

The distributing lines are sometimes under the care of the piper, sometimes under the direction of the engineer, and the connections to the tools are everybody's business.

When a pneumatic tool gives out it is sent to the tool room and the first available man is directed to fix it up. As time goes on first one man, then another, will work on air tools until all are expected to be competent in that line with an actual experience of perhaps days, where months would not be too much to make an expert.

Hose; not the especial care of any person will rapidly deteriorate, and it is no uncommon thing for oil to be put into hose to be driven through it to the tool. It should be needless to say that such practice, besides being wasteful, will soon destroy hose, besides sending dirt with the oil through the tools to their serious injury.

Finding at length that air power is expensive, the manager selects from his force a man whom he knows to be faithful and directs him to assume care; sometimes of the tools or hose only, sometimes of tools and hose, sometimes of tools, hose and pipe lines, and sometimes of the whole plant, and so a new air man is born. If he is intelligently efficient, a long stride has been taken, and results that will be appreciated by the management will soon appear.

In a case somewhat similar to the above I was appointed air man on a plant of about 150 miscellaneous tools on ship work. We now have nearly 600. At that time the distribution, with the exception of 1,500 feet of 5-inch main, was all through 2-inch lines varying in length from 300 to 1,300 feet, and as the initial pressure of 100 pounds had sometimes been found to fall below 30 on ships, new compressors had been contracted for.

Having pronounced ideas on the growth of air plants, I suggested at least 6-inch pipe for mains to the water front, and 4-inch distributing mains; was listened to with attention and, I presume, was thought a visionary or crank. At all events, there was no move for improvement till after the new compressors were installed, which did not materially change existing conditions.

The manager, having occasion to visit some establishments of a similar character, returned and allowed everything I had suggested and contracted for more compressors to bring our capacity up to 4,000 feet instead of the 1,500 feet originaly believed to be all that would ever be required. At the same time machine tools were purchased and a small shop placed in my charge for the repairing of hose, pneumatic tools and appliances.

In laying the new mains the same attention was given to inclining the pipes for drainage that would be given to steam, and traps were installed at the low points that automatically eject condensed water and are, in my opinion, preferable to after-coolers, because after-coolers may not reduce the temperature to that of the outer air and may thus allow uncondensed water to pass, while traps placed four or five hundred feet from the compressor are very effective. These traps should be protected from frost and, if continuous freezing weather exists for a week or more, I have made it a practice to heat them once in three or four days to make sure that the passing air—which may be below freezing temperature—shall not form ice in them.

The method of heating traps varies with conditions, but I find good results from placing them so that they can be submerged in hot water that can be drained off when cool. This measure is simply precautionary and I cannot vouch for its necessity.

Some pneumatic tools are provided with air strainers designed to keep grit or scale from entering the working parts, but many are not, and many more are provided with ostensible strainers that are of no practical value, being so small as to clog quickly, and usually constructed with wire gauze that sooner or later breaks and enters the tools, causing as much damage as they are designed to prevent.

Our method is to lead lines of 1½-inch hose to the vicinity of the work and to connect on the end of this hose manifold outlets mounted on an enlarged chamber across which is stretched a diaphragm of bunting. Bunting makes an efficient and lasting strainer and can be very cheaply maintained.

For fixed shop connections, a different form of manifold is constructed, but it also contains the bunting strainer, which, in most cases, lasts about two years before needing renewal.

Carrying 100 pounds pressure, we can supply 15 miscellaneous tools or 30 scaling hammers from each 1½-inch hose, and if the workmen follow instructions and blow out the small hose before connecting tools, nothing more harmful than rubber will ever enter a tool.

We had a good deal of difficulty in finding the best ¾-inch hose adapted to our work, and have now decided that a marline-woven covered hose is the most satisfactory as well as the most economical in the end, as the marline protects the outside of the hose from the action of the weather, the hose is lighter and more pliable and—if the condition of the hose seems to warrant it—broken places in the covering can be served so as to be nearly equal to new.

Certain specifications have been made regarding our hose that are, I believe, not usual with purchasers, but the hose as now received certainly wears longer than any previous purchases.

We require that marline-woven air hose shall stand a hydrostatic test of 500 pounds and that the covering shall extend from coupling to coupling, as this gives support to the weakest part of the hose, which is that covering the end of the coupling sleeve. It is obvious that coupling clamps must be applied *outside* of the covering, and some hose manufacturers refuse to do this, claiming that clamps cannot be safely applied in this way. But our answer is that we had successfully practised this method for more than a year in our repairs before asking it of the manufacturers, and we have purchased thousands of feet of hose fitted in this manner.

It should be stated that we use a hose clamp of our own design for repairs, that is made in three parts and drawn together by three bolts, which I believe to be preferable to those furnished by any manufacturer. We use nothing but screwed couplings, and by screwing the male thread of the ¾-inch hose into the valve on the manifold and making a special fitting for connecting the leaders—which are 6 or 8 feet of 7-16-inch hose leading from the ¾-inch hose to the tool —to the female end, we reduce the necessary number of joints to the minimum.

We also use leather for all gaskets, and in the purchase of valves select those of such design that when they become leaky the original seat can be replaced with leather.

We have valves perfectly air-tight that were fitted with leather seats more than two years ago and never renewed.

Hydraulic Compressed Air in Connecticut.*

The use of compressed air for the development and transmission of power is very old. On the walls of a tomb in Egypt, there is a representation of two men standing on leather bags of air, alternately pressing them down with their feet, to produce a blast for a furnace. The ancients used compressed air in blow guns, in forming jets for fountains, in blasts for forges, and for other purposes. Papin used compressed air for forwarding packages, in tubes, two hundred years ago in France. It has long been used in diving-bells and in tunneling. Brunel used it in tunneling under the Thames in 1825. In 1849 compression was proposed to be performed in stages, with inter-coolers between each stage, to get 750 pounds pressure for locomotives.

The first successful use of compressed air for the transmission of power, as now known and used, was at the Mt. Cenis tunnel in 1861, where air was compressed to five atmospheres by two methods, one being by pumps or rams in which water was the piston, but though the air came in contact with the water, it was only slightly cooled, at the surface of the water and around the walls of the cylinders.

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* A paper read by J. Herbert Shedd, Consulting Engineer, Providence, R. I., before the March, 1905, meeting of the New England Water Works Association.

About 1870, at Vienna, and later in Paris, a system was installed for working and regulating a great number of clocks by the use of compressed air from a central station. This soon developed into an extremely important system of power transmission. Paris now has great compressor plants supplying 25,000 horsepower, and more than 50 miles of distribution pipes, supplying air at 75 pounds pressure to thousands of customers, who use it for every purpose, from cooling beer or dusting furniture, to running electric light dynamos. A little stove, with a common kerosene lamp, is used to heat the air before use in the small motors. The motors in use range in size from one-tenth of a horse-power to 150 horse-power, most of them being less than one horse-power. They are started or stopped by simply opening or closing a valve.

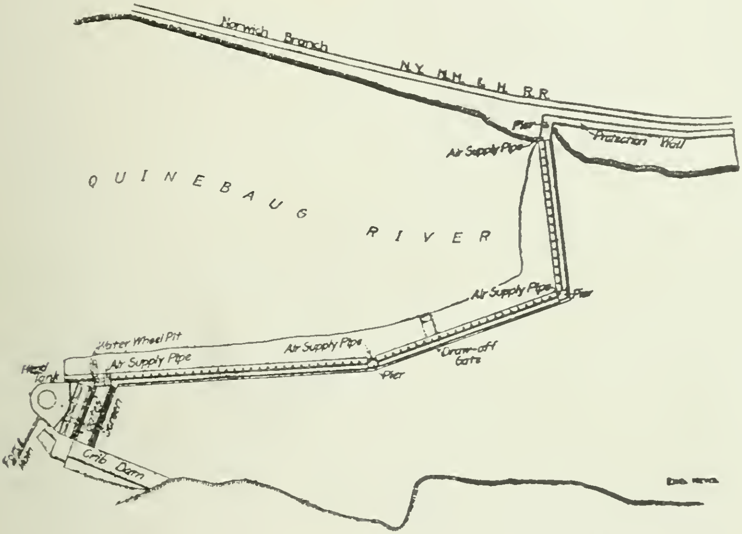


FIG. 1.

The cooling of the air while it is being compressed, and reheating it for use in engines, are matters of great importance. If the air is cooled as it is being compressed, the volume will be much smaller, under a given pressure, than the same amount of air would occupy if allowed to retain the heat caused by compression. Then again, if the compressed air is heated just as it enters the engine, the volume will be much increased, while the same pressure is maintained. The economy in using coal for developing power in this way is so great that four or five times as much power can be secured from a pound of coal, through reheating the air, as can be secured through making steam. The reason for this is chiefly that a great portion of the heat of the coal is absorbed, and becomes latent and ineffective, in turning water from the fluid to the gaseous form in making steam power, and no such loss occurs in expanding the air and so increasing *its* power. It is feasible to increase the power of an air engine fifty per cent., by such reheating of the air.

The method of compressing air by entraining it in water, and causing it to pass down in the water to a great depth, so that it is subjected to a great weight of this incompressible fluid, is an ideal one. In this way the air is compressed isothermally, the heat of compression being absorbed steadily by the surrounding water, and the air is, therefore, delivered to the pipe line as cool as the water through which it has passed. The compressed air is also drier, or will be when used in the motor, than the atmospheric air from which it was withdrawn. This comes from the fact that the surrounding water absorbs the moisture precipitated from the air as its capacity to hold water is diminished under compression. A dry, cool air is thus secured for the distribution system, comparatively free from the danger of freezing on its way to the motor, or on its expansion in or from the motor. Where there is no moisture to freeze, there is no freezing.

I have been asked to describe to you, briefly, some of the features of a recent installation of a plant for the hydraulic compression of air, to be transmitted a few miles for use in the development of power. This plant is on the Quinebaug River, just above its junction with the Shetucket River in Connecticut, and alongside the track of the Norwich & Worcester Railroad, near the point where the track passes through a tunnel; which fact has given the name of the tunnel privilege to the falls which have been utilized by the establishment of this plant. At this point the river passes through a narrow, rocky gorge, and to utilize the full fall available, the surface of the water above the dam must be brought within a few feet of the level of the track. This condition made necessary the adoption of devices for limiting the height to which flood water would rise over the proposed dam, so as not to overflow the railroad track. For this purpose the length of overflow on the dam was increased, so far as practicable, by laying the plan of the dam somewhat in the form of the letter Z, thus about doubling the length of the overflow of the dam, and of course, correspondingly decreasing the thickness of the sheet of freshet water passing over it. Another device consisted in the establishment of automatic flashboards, so designed that with the water at the normal stage of the river, the flashboards would retain their position and hold the water to the full allowable height, but upon the increase in the discharge of the river, and consequent rise of the surface above the level of the flashboards, they would turn to a nearly horizontal position and so open a passage for the water to a level between three and four feet lower than the top of the flashboards when in their normal positions.

In the plan, Fig. 1, the positions of the screen, gates, and compressor tank are to be seen upon the left bank of the river. The shore and the bed of the river at this point are of ledge, but the bed of the stream had been filled in places to a considerable depth by bowlders unattached, though compactly placed, and it was not considered safe to form the dam upon any other material than the solid ledge in place. Laborious and expensive excavation was necessary in some places to uncover the ledge, and at points excavation was made considerably below the sea level.

To protect the men from inundation by the water in the river, coffer dams were erected, covering successively different portions of the excavation, and these coffer dams were generally formed of square-edged planks, set vertically and supported by timber cribs.

The dam is formed of what is called Cyclopean concrete, consisting of Portland cement mortar with stone, gravel, and sand of varying sizes up to those as heavy as could be handled by the derrick. These materials were so mixed that no two pieces of large size would touch each other, but every piece was surrounded and encased in materials of less size down to the fine powder of the Portland cement. These materials were so placed as to form a dam of the necessary stability, and the form of section for this purpose, as adopted, is shown in Fig. 2.

The materials, while the cement was setting, were held in position by forms of plank set to enclose the dam and removed when the mortar had set sufficiently for that purpose. The positions of some of these enclosing forms, together with the character of materials used, may be seen in Fig. 2.

When the concrete structure had arrived at a sufficient elevation to form the floor of the inlet to the compressor, the surface was carefully leveled and floated and troweled to the right elevation. This was at the lower end of the dam on the left bank of the river.

It was necessary to control the access of water from the river to the head tank of the compressor, and for this purpose substantial mill gates were used. These gates control three openings, eleven feet wide and eleven feet high each. These gates can be operated by a small water wheel set in the head wall of the dam.

In constructing the dam it was necessary to put it in in sections, so that the river might be diverted and passed through or over one section while another section was being constructed. In making a junction of a new section with one which had been previously built, care was taken to lock the two together as securely as possible to obtain a tight connection and one which would have the greatest available strength. The surface of a section, partially constructed, at one end of an angle in the dam, and where preparations were making to begin the construction of a new section, is shown in Fig. 3.

The flashboards, designed to open and furnish additional opportunity for storm water to escape, are substantial structures, formed of white oak and steel, in sections six feet in length and three feet seven inches in height. Efforts have long been made to construct automatic, or movable dams, which would open when the quantity of water flowing in the river required it, and would, of themselves, close again when the water in the river had returned to a safe level. Nearly seventy years ago a dam was formed of a series of shutters, in France, with the axis so placed that the pressure of water above and below would be equal when the level of water in the pond stood at the top of the flashboards; that is, the axis was one-third the height above the bottom of the flashboards. When the water rose above this point, the pressure became unequal and was greatest above the axis. When the dam opened and relieved the pond, it was found that the dam would not set itself up against the stream, after having once opened, and therefore the automatic action sought for had not been accomplished. In the present instance the flashboards are so hung that they do automatically, and gradually, open and close as the water rises above the crest or falls to a level with it. Some details of these flashboards are shown in Fig. 3, and a view of the top of the dam with

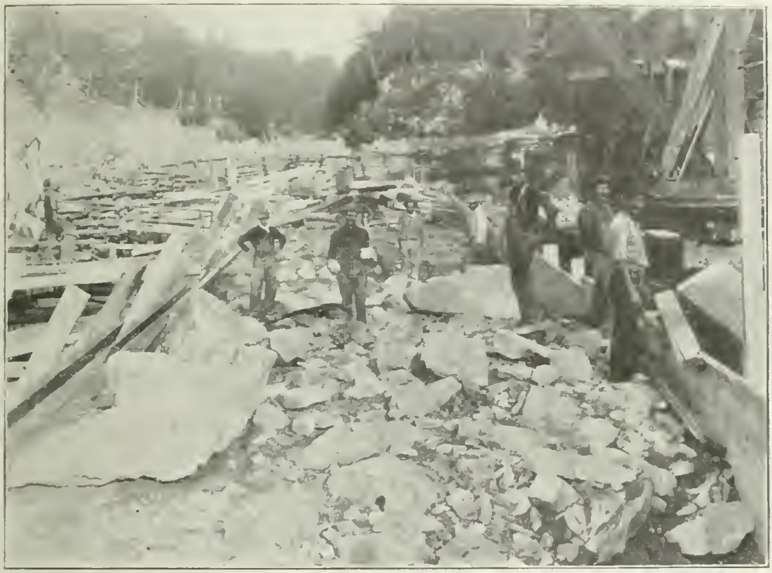


FIG. 2. SHOWING FORMS AND CHARACTER OF CONCRETE.

flashboards wedged in various positions is shown in Fig. 6. When the water in the pond is at its normal level, and the flashboards are in their normal positions, the point of bearing on the axis is at one-third the height of the flashboards above the bottom, or at the centre of the pressure of the water. The lower portion of the flashboard is so weighted that the centre of gravity of the moving parts is below the point of bearing, and upstream from the perpendicular line drawn through the point of bearing. The flashboard is hung on a rolling hanger, confined in place, having such a form that as the height of water against the dam increases and tips the flashboard, the resisting point of the flashboard rises to meet the new centre of pressure and the resultant forces produced by the moving water. In its new position, the resistance of the flashboard to motion, and the forces tending to move it, are in equilibrium so long as there is no change in the volume of water flowing, but as this volume changes, the flashboard assumes a new position, either wider or less open, as the quantity of water continues to increase or decrease. This result arises from a combination of overbalancing weight, in the lower part of the flashboard, aided by an equalization of the areas above and below the point of bearing, on which the forces, caused by the moving water, act when the dam is open. The device is simple and massive. The frames on which the hangers roll and to which they are confined are well anchored to the masonry and are so constructed as to furnish a stop to the flashboard when it is fully open, to prevent the possibility of its passing beyond a point where it could be favorably acted upon, as the level of the water in the river retreats to its normal height. These flashboards have now gone through several winters, with their freshets, accompanied by ice, logs or uprooted trees or other floating matter and have withstood all this without resulting injury, and they have worked satisfactorily in allowing increased

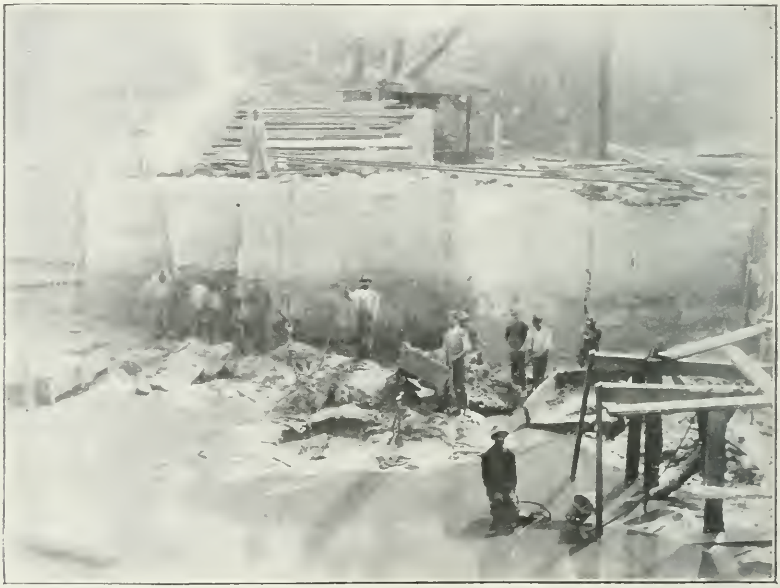


FIG. 3. JUNCTION OF SECTIONS OF THE DAM.

opportunity for the escape of freshet water and in withholding the pond level to its normal height.

Having now brought the water to such an elevation that we can avail of a sufficient fall between its surface and the tail water we will proceed to a further consideration of the Norwich compressor plant with the available fall of 22 feet. In order to compress the air to a sufficient degree by submitting it to the weight of a head of water, a shaft was sunk vertically to a depth 208 feet below the bed of the river or 215 feet below the surface of the tail water, and at the bottom this shaft was enlarged into a chamber to contain the air separator. The shaft is 24 feet in diameter and the chamber at the bottom is 52 feet in diameter. Opening out of the chamber at the bottom is an air reservoir regulator, in the form of a tunnel from 15 to 20 feet in height and 18 feet in width and having a length of about 100 feet. Suspended in

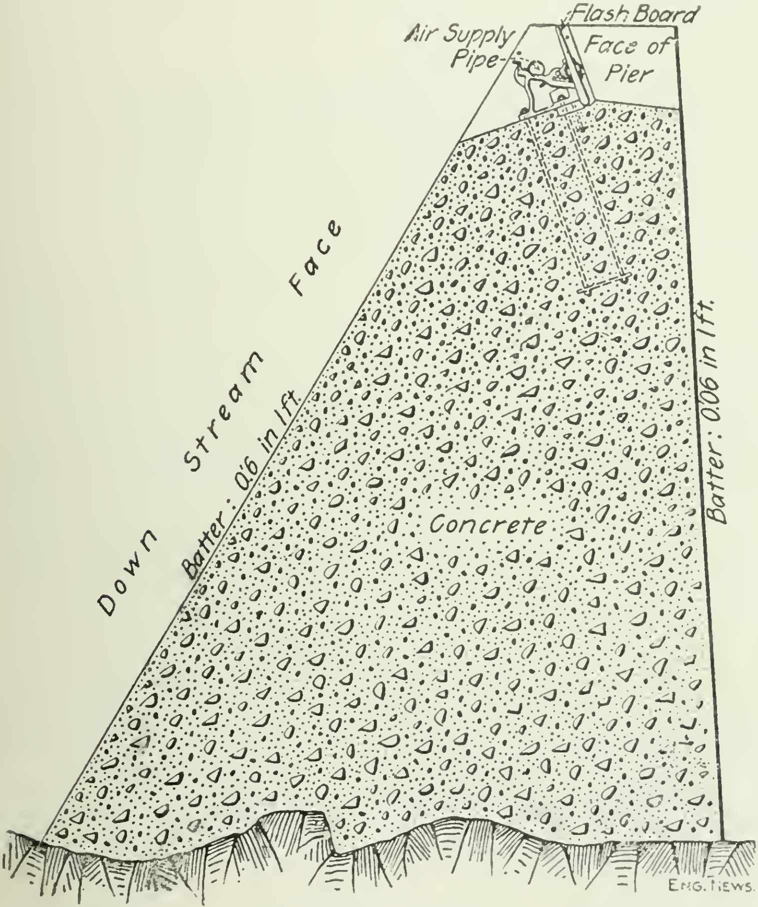
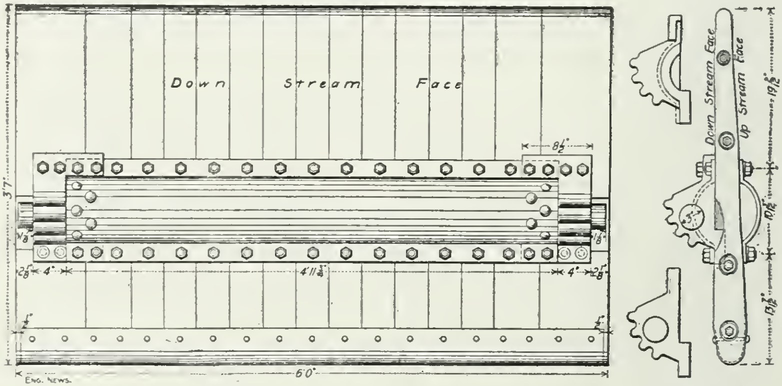


FIG 4.

the middle of the shaft is a downflow pipe of steel, about 14 feet in diameter, connected at the top with the head tank, through which water is received from above the dam, and at the bottom with a separator chamber. This chamber is surmounted by an air reservoir, to contain the compressed air when separated from the water in which it had been entrained, and with which it had been carried to the bottom of the shaft. From the air reservoir over the separator, a 16-inch leading main rises to the surface, and is laid toward Norwich, conveying air under about 90 pounds pressure for the use of the engines at the several establishments employing it for power. A general idea of the shaft, down-flow pipe, separator, leading main, etc., can be obtained from Fig. 8.



Side Elevation.

End Elevations.

FIG. 5.

In sinking this shaft through the ledge, below the bed of the river, it was found that the upper portion was not sufficiently strong to serve for the permanent walls of the shaft, and for a considerable distance the excavation was lined with concrete, formed by filling a space between curbing, inserted for the purpose, and the surface of the ledge as excavated.

After the shaft and its appurtenances had been completed, the erection of the head tank, downflow pipe, and separator, formed of steel, was proceeded with. During this time, the flow of the river, at whatever stage, was passed over the dam, or through a sluiceway.

Fig. 9 is a view of the head wall, with a portion of the dam, looking diagonally down-stream, during the construction of the separator.

After the steel work had been completed, all the false works and accessories were removed, and water was turned through the apparatus.

When the compressor is in full operation, entraining the air and supplying it to the air chamber and leading main, the collection of air may be more rapid than its withdrawal for use in engines, or for other purposes. To avoid the disturbance which would be likely to occur if the accumulated volume in the air chamber should force the line of separation between the air and water below the bottom of the downflow pipe, and thus allow of an eruption of air through the downflow pipe and head piece, provision is made for a blow-off, or escape of air to the atmosphere, through a blow-off pipe, having an aperture at the bottom higher than the level of the bottom of the downflow pipe, and through this aperture the excess of air supplied to the separator may escape, before the water line in the air reservoir is carried low enough to cause damage. A view of the entire plant, taken while this escape pipe was in operation and blowing off a surplus of air mixed with water, is shown in Plate III, Fig. 2. When this blow-off pipe was first set in position it was turned so as to discharge nearly at right angles across the river, and it was found that the air and water sometimes escaped with such force that it would drench a passenger train passing over the track. The direction of the pipe was then changed so as to discharge diagonally down the river, as now represented, and where it could do no harm.

The process of entraining the air to the separator before its passage with water through the compressor is accomplished by submerging orifices, or air pipes, below or in contact with the surface of the flowing water; such apertures or pipes having proper channels for a free communication with the outer air. The air being in contact with the flowing water is entrained by it, and a partial vacuum being caused thereby, a sufficient pressure is induced to cause a free flow of the outer air through its proper channels to the water. Having been entrained there, at the ordinary atmospheric pressure, the air is carried down in bubbles with the water, and is steadily compressed as the depth of the water increases until, as in this case, it reaches a pressure of about seven atmospheres. Having escaped from the water by floating out of it as the water passes slowly through the separator, it retains, in the air chamber, the pressure due to the weight of the column of water having the height equal to the difference in level between the tail water escaping from the apparatus and the line of separation in the

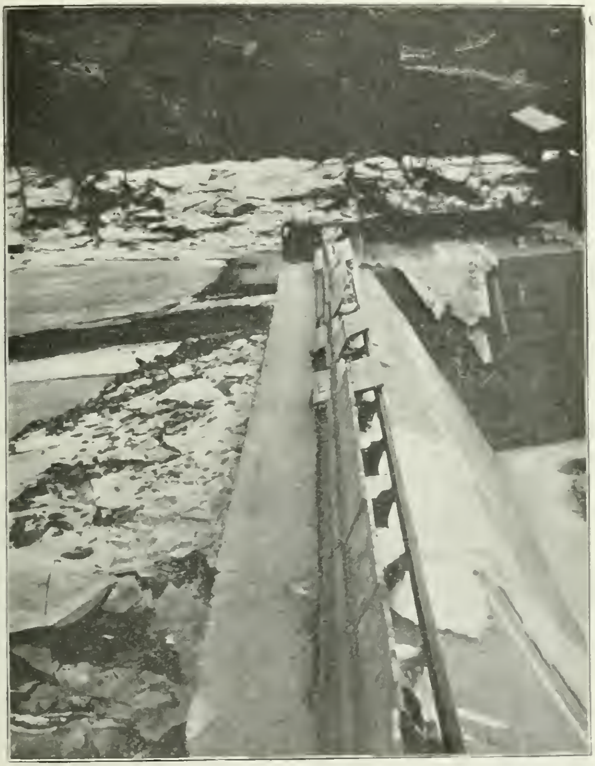


FIG. 6. VIEW OF CREST OF DAM, SHOWING AUTOMATIC FLUSHBOARDS.

air chamber between the accumulated air and the water out of which that air has floated.

The volume of air which can be carried down with water depends somewhat upon the fall, or the difference of level between the pond water and the surface of the tail water. The greater that difference of level, within reasonable limits, the greater the volume of air which can be carried down with water. In this case, apparently the volume of air is about one-third that of the volume of water passing through the apparatus. The combined volume, formed of a mixture of air and water, is of course lighter than a column of solid water, and the aërated column cannot be quite so much *longer* than the solid water column as is represented by the amount of the fall, because a certain amount of force, represented by a portion of the fall, is necessary to cause the mixture of air and water to flow through the separator. I know of no experiments bearing directly upon this matter, but it seems probable that a limit of the volume of air which could be entrained and carried down by a surrounding volume of water, would be reached when the aërated column is about fifty feet longer than the solid water column.

There are various means of measuring the amount of air which may be supplied from a given source, the most satisfactory of which probably is to pass it through an air meter, having the usual recording attachment operated by clockwork. Various observations have been made upon the amount of air which would pass through an orifice, shaped approximately like the contracted vein formed when a fluid passes under pressure through an aperture in a thin plate. The volume, or weight, of air in pounds per second, may be ascertained, with reasonable accuracy, by taking the area of a circular orifice of this form, in square inches, and multiplying that by the *absolute* pressure, in pounds per square inch, entering the orifice, divided by the square root of the *absolute* temperature, in degrees Fahrenheit, and the whole multiplied by a coefficient vary-

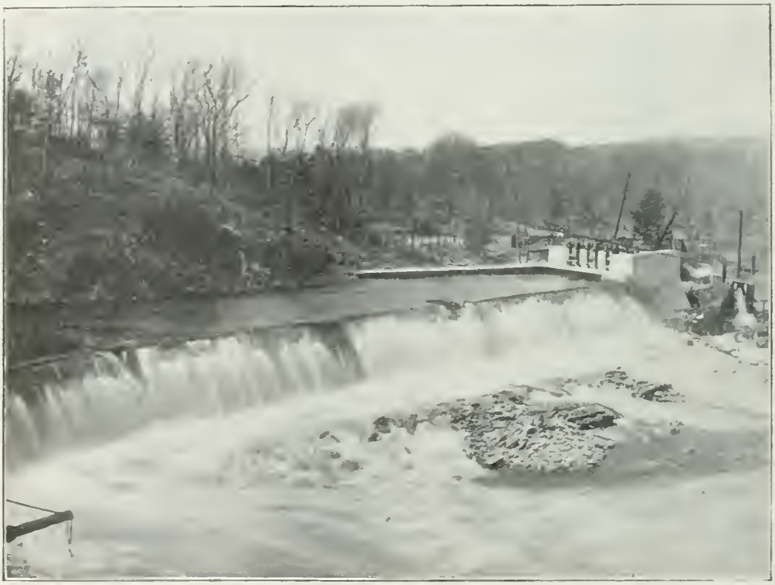
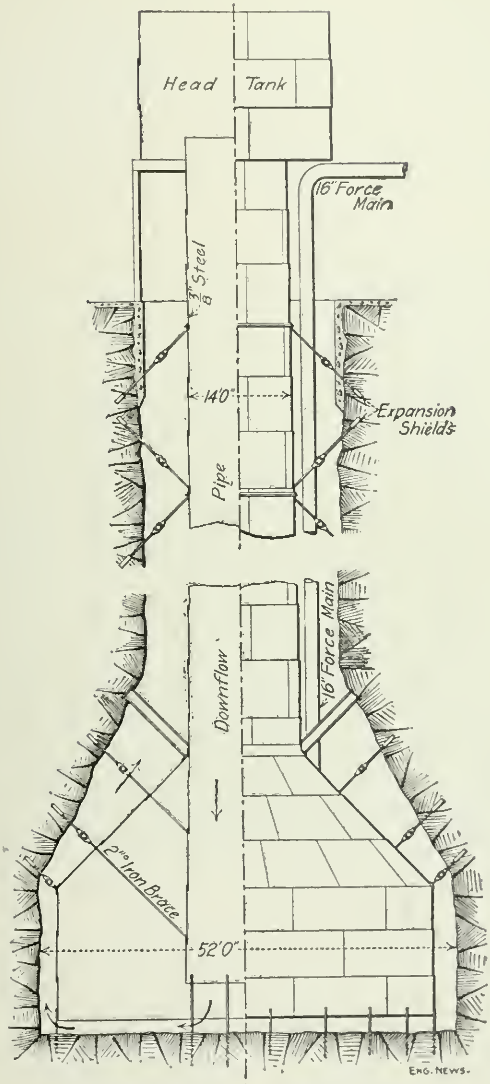


FIG. 7. VISIBLE PORTION OF COMPRESSOR IN ACTION.



$\frac{1}{2}$ Section. $\frac{1}{2}$ Elevation.

FIG. 8.

ing somewhat with the area of the orifice. For an orifice of one inch diameter the coefficient may be taken at .53.

It is of great importance that the pipes leading the compressed air from the source of supply to the point of use shall be tight, and it is much more difficult to secure such tightness with air than it is with water, or even with steam. Cast iron as a material for such pipes has been very successfully used, but if the joints have been formed in one piece with the pipe, they cannot be successfully made tight by calking with lead, in the manner found to be safe in conveying water.

The joint most extensively used in Paris, and found to be satisfactory there, is formed upon cast-iron pipes having a plain spigot at each end; having brought two pieces of pipe together, place over the joint so formed a short sleeve, nearly fitting the pipe, and long enough to fully cover the joint under such variation of position as may arise in practice. Against each end of this sleeve is placed a rubber ring or gasket, and these rubber rings may be pinched against the ends of the sleeve by other properly formed sleeves or hubs, encircling the pipe and having flanges through which bolts may pass, the hubs being drawn toward each other by nuts on the bolts, thus squeezing the rubber ring between the hub, sleeve, and the pipe. It is necessary to select a kind of rubber well adapted to this service, in order to secure a permanently tight joint, but with materials properly selected and properly applied, the leakage has been found to be so small that it may be neglected in estimating the amount of air which may be delivered from a distribution system.

In cases where it is desired to substitute another form of power in works where steam engines have been used, compressed air has a great advantage over electricity, in the matter of economy. It is not necessary with air, as it is with electricity, to install new motors at the works, but the engines which have been previously used with steam are well adapted for use with compressed air, thus avoiding considerable expense which would be necessary for electric motors.

In Magog, Canada, I inspected the operation of a plant where air had been compressed by water, in a manner similar to that in operation at Norwich, and where a number of engines were running to drive printing presses for printing cloth. I asked the machinist if there was any special trouble in substituting air for steam in an ordinary engine. He took me into the machine shop, where an engine was driving the machines, and operated by steam. A connection had been made to this engine from the air compressor, and two pipes, one leading steam and one leading compressed air to the engine cylinder, lay side by side. The machinist took hold of the steam valve with one hand, and the air valve with the other hand, and gradually closed the steam valve and opened the air valve, until the engine was running entirely with compressed air instead of with steam. After running a few minutes in this way he reversed the process, gradually closing the air valve and opening the steam valve, until the machinery was being again driven entirely by steam power. Both operations were performed without any apparent change in the running of the lathes and planers, or other machinery, and it is probable that no machinist in the shop knew that any change in the power had been made. The only disturbance during the entire operation, that I noticed, was a slight sound of thumping in the engine, when the air was shut off and the steam re-introduced, probably caused by the condensation of a small amount of steam when passing into the cylinder, which had been cooled by the compressed air. Any non-condensing steam engine seems to be well adapted to driving by compressed air, whether used at full stroke or under cut-off, the substitution of air for steam being made without changing the engine.

I have before mentioned that a great economy in the use of compressed air for power purposes may be secured by reheating the air just as it enters the engine. An economy of from 30 to 40 per cent. is sometimes possible in this way.

Compressed air has a great advantage, when it is desired to use transmitted power intermittently, and with periods of non-use intervening with periods of use. There is no loss in maintaining this power when it is not in use. There is no leakage like the leakage of electricity. There is no reduction of pressure like that caused by the condensation of steam. The whole power is available whether used continuously or at intervals.

Mr. Sickman—Under what conditions would that be obtained? When you are using a great quantity or a small quantity?

Mr. Shedd—It is when using the quantity to which the compressor is adapted. I believe the local engineer has said he thought he could obtain somewhere near eighty per cent., but we have never, to my knowledge, accurately measured the efficiency at this point. The velocity of the water when it is entraining the air seems to be about eight feet per second when it is doing its best work, and under those conditions the efficiency, as I say, in the experiments in which I took part, was a little over seventy per cent.

Mr. McKenzie—What is the method of introducing the air into the water as it passes down?

Mr. Shedd—That has been done in various ways. At Magog it is done by a series of three-quarter inch pipes surrounding a circle, the upper ends above the level of the water and the lower ends at the point of the greatest velocity of the water as it flows into the down-flow pipe. The water passing by the end of the pipe tends to create a vacuum there and the air is drawn in and goes down in bubbles with the water. At Norwich the headpiece is a sort of gridiron with each bar hollow, open on the lower side and supplied with air at the ends, and the water passing down between these gridiron-like bars, the air passes horizontally through the bars into the water as it passes by. There is a plate nearly across the pipe, you might almost call it a pipe, a gridiron bar with a quarter-inch aperture on each side. The headpiece is under three or four feet of water all the time and the pipes to these gridiron bars rise above any possible level of the water in the headpiece. They are 12-inch pipes with a 36-inch centre pipe.

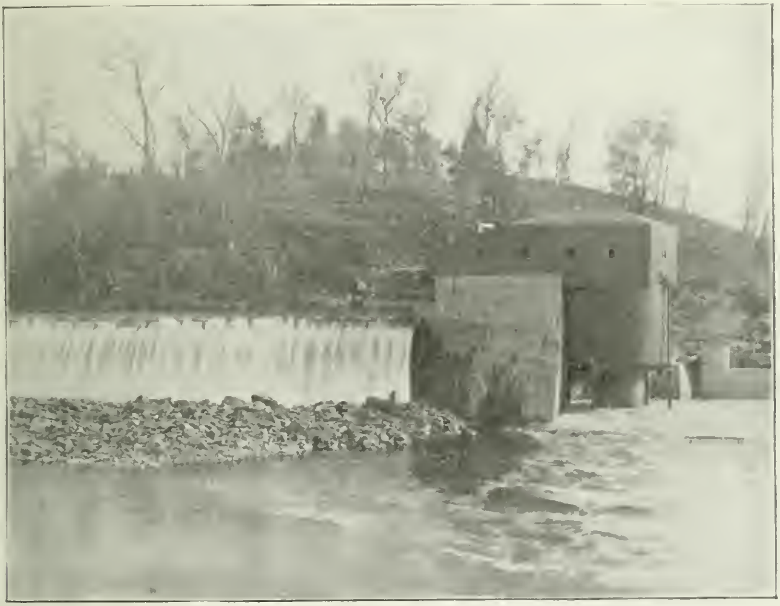


FIG. 9. VIEW OF PORTION OF DAM-COMPRESSOR UNDER CONSTRUCTION.

Mr. Fuller—I should like to ask Mr. Shedd with regard to the excavating of the well, whether that was expensive? I suppose there was a good deal of water which had accumulated which had to be constantly pumped.

Mr. Shedd—Very little, indeed; it was very favorably situated in that respect.

Down perhaps one hundred feet there was one seam which developed a pretty good flow of water, but otherwise the ledge was tight. That inflow was taken care of by an excavation in the side of the shaft and a dam between that and the shaft itself, making a well, out of which the water was pumped. We then had no more water to amount to anything until we were at the bottom of the shaft.

Mr. Fuller—How much did that excavation cost per cubic yard?

Mr. Shedd—I shall have to tell you from memory, but I think it was $3.50 a cubic yard.

Mr. McKenzie—Are there any patents on the general process of compressing the air?

Mr. Shedd—Yes. That was patented by a Canadian by the name of Taylor, in England and in this country.

Mr. McKenzie—Is there a royalty paid?

Mr. Shedd—That I don't know. I don't know what their business arrangement is, but I think the Norwich people are licensed by Mr. Taylor.

Mr. Sickman—What is the temperature of the exhaust at the engine?

Mr. Shedd—That varies. It is very low in cases. It has been low enough to freeze. We had no difficulty in Magog, but here there has been slight amount of moisture, and the temperature due to expansion is low enough to freeze that moisture unless the air is reheated. But when the air is reheated, which would, of course, be done in all cases if you are seeking economy, then there is no trouble of that sort. There have been a good many experiments made on the temperatures both of the air admitted and the air discharged, but I don't remember the figures. Our experiments showed that from about a third to a half as much moisture was in the air delivered by the compressor as was in the atmospheric air from which it was drawn; that is, the air has been made dry by being enclosed in water.

Mr. T. W. Mann—In 1876, I think it was, I was in Rochester, and they had a system of two tubes which were air-tight and they let the water in at the bottom and compressed the air in one tube while the water was going out of the other tube, keeping a balance of pressure. I wonder whether that would not be a pretty good way to keep the moisture out.

Mr. Shedd—I don't know, myself, about the process the gentleman speaks of, but I should think it might be very much in theory like a process designed by Mr. Joseph P. Frizell, twenty years or more ago, for compressing air. He had a shaft above a dam down which water went carrying air with it and then he had a horizontal tunnel and a shaft below the dam so that there was a difference of level below and above the dam, and at an intermediate point he had a chamber in which the air was collected. I should think that would be similar to having two pipes. There have been a great many ways of entraining air and compressing it by water, and I think Mr. Frizell's was perhaps the first really practicable scheme. But that never has been put into commercial use, so far as I know, because it was an expensive process as he designed it.

Mr. Atkinson—I happened to be in Liverpool some twenty years ago and went to the great docks, and I found that all the power used there was compressed air. Of course, it would be very dangerous to have fire among the merchandise there. I am not mechanic enough to understand the details of it, but if any of you visit Liverpool I think you will find that the use of air pressure throughout the docks is very extensive. I once gave a hint to a mill man which may be worth the telling here. You all know that the fiber of cotton is exceedingly susceptible to the changes of temperature and humidity. Now, the air which goes down through the wheel pit gets washed and cooled. In the case of the gentleman to whom I refer the basement of his mill was on a level with the tail race, and in hot weather it was very damp and very objectionable. I suggested to him to put an air drum over the water in the wheel pit and to carry the cool, dry air through a pipe into his picker room and from his picker room into the spinning room, and thus overcome the humidity. He adopted the suggestion and it worked very successfully. That same thing can be done in many places. There is an enormous quantity of air which goes down through the wheels, even without any artificial method of carrying it. I have been told that at a summer resort in Austria a mountain stream has been used to compress air, and one of the show features is to let the cool air out in midsummer and produce an artificial snowstorm. There is a head of about eight hundred feet which gives an enormous pressure.

Our old friend Sam Webber had an entirely new device for compression which he has described to me, and it made such an impression on me as it would naturally make on a "duffer." It was entirely different from Mr. Frizell's, and quite different from the one which has been described to-day. Then, I remember some twenty years ago the Plymouth Cordage Company desired to install an engine for hauling heavy stuff through their yard, and we objected to it. There was then devised an air locomotive and we sent the designs to the Boston Locomotive Works, who built it without giving any guaranty that it would be efficient, but that little air engine is operating to-day, carrying around the heavy stock in the yard. When I returned from Liverpool I reported to the Cotton Manufacturers' Association that the English were a generation ahead of us in this country, but we appear to be catching up with them now in the use of air pressure.

Each method of producing or transmitting power, whether by steam, or gas, or oil, or electricity, or compressed air, has advantages of its own under favoring conditions, but the use and value of compressed air seems heretofore to have been but partially known and poorly appreciated. I quote from Richards: "The use of compressed air has been slow of development, and is still backward, but at this writing I am able to enumerate two hundred distinct and established uses of compressed air, and in more than ninety per cent. of those uses electricity is absolutely inapplicable, and in the remainder, which form a field more or less open to other agencies besides either air or electricity, the air generally has the advantage."

In the Norwich plant the production of compressed air is very uniform and the pressure is held steadily at about ninety pounds while the compressor is in operation. A card from the pressure recording gage shows that the pressure for the whole twenty-four hours varies only about

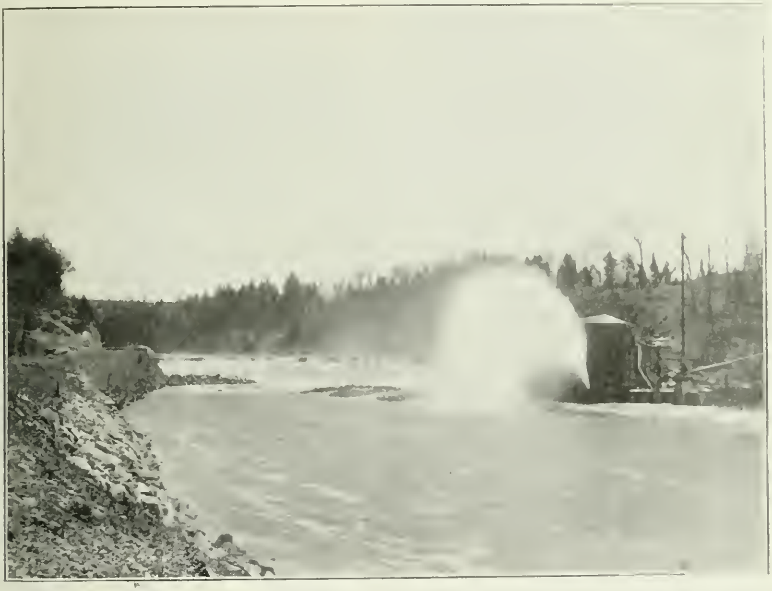


FIG. 10. BLOW-OFF IN OPERATION.

two pounds, standing at just ninety pounds nearly all the time. The water, when this card was taken, was turned through the compressor, beginning at a little before five o'clock in the morning, and in about ten minutes the card represented the full amount required to carry the pressure from that existing through the night to the ninety pounds which is the standard pressure. At about fifteen to twenty minutes after five in the morning, the distribution pipes are blown off, to free them from any possible moisture which may have gathered over night, and this operation is shown by the reduction in pressure of about one pound. This pressure is, however, restored in amout ten minutes, and from that time to midnight the full pressure of ninety pounds is uniformly maintained. After that time until 4.45 in the morning the pressure shows a gradual reduction of about two pounds, but I am informed that this is not probably the result of leakage, but that small amounts of air are drawn, for various purposes, during that period in the night. Daily cards are taken, the change from one card to another being made at about nine o'clock in the morning.

The air delivered from the Norwich plant is in use in over forty engines, and its employment is a source of great satisfaction to the men who formerly were obliged to reach the works by 4 or 4.30 in the morning, to get up steam and have everything ready to start at 7, and who now have the comfort of waiting until a few minutes before 7. Upon arrival they simply turn a valve and the machinery starts off at full speed.

DISCUSSION.

Mr. Edward Atkinson—I should like to ask if this power is sold.

Mr. Shedd—It is sold to various small factories in Norwich and vicinity, which formerly used steam and are now using compressed air in its place. I have nothing to do with the financial part of the business, and I do not know what the prices charged are, but these concerns at least have preferred to use air at the price at which it is sold rather than steam, which they had been using.

Mr. Atkinson—It was a question in my mind as to whether at the price at which it is sold it pays the promoters.

Mr. Shedd—That I am unable to say.

Mr. T. H. McKenzie—Are the pipes laid as water pipes are, below the frost?

Mr. Shedd—No; most of them are about four feet deep, but really there is no occasion to lay them below frost, except that it is desirable to have them so low that they will not be thrown by the frost.

Mr. McKenzie—Why does the air blow-off blow both water and air?

Mr. Shedd—Because the inlet to the blow-off pipe is just at the level of the air and water, and as the air begins to pass out it carries water with it, so that water and air are discharged.

A question has been asked me as to how the flashboards have worked in practice. The only trouble they have had from the flashboards has been that when they are open leaves flowing in the stream sometimes catch in the seats and flashboards do not entirely seat themselves afterwards, so that there is a little leakage for a time until the leaves are cleared from under the seat.

Mr. Frank L. Fuller—I should like to ask Mr. Shedd in regard to utilizing the different amount of flow at different seasons of the year. I think all the slides which were put upon the screen showed water running to waste.

Mr. Shedd—Yes; the plant is adapted to 1,500 horse-power, and the stream is usually capable of developing considerably in excess of that amount of power. Water, of course, is running to waste over the dam when there is only 1,500 horse-power or less going through the compressor. When the compressor is taking a less quantity, adjustment is made in the head-piece.

Mr. Fuller—I presume it is quite a variable stream.

Mr. Shedd—Yes; but it is pretty well reservoired. As near as I remember, there are forty-three different storage reservoirs on that stream. It rises in Worcester County in Massachusetts, and there are a great many mills on the stream; it has been very well developed for manufacturing purposes.

Mr. Fuller—Could not another compressor be used when there was plenty of water?

Mr. Shedd—Yes; there is an opportunity to place another alongside of this one. Everything has been so arranged that no disturbance would occur if another compressor of equal capacity were set alongside of this.

Mr. McKenzie—Is there any patent on the apparatus for the flashboards?

Mr. Shedd—Yes, there is.

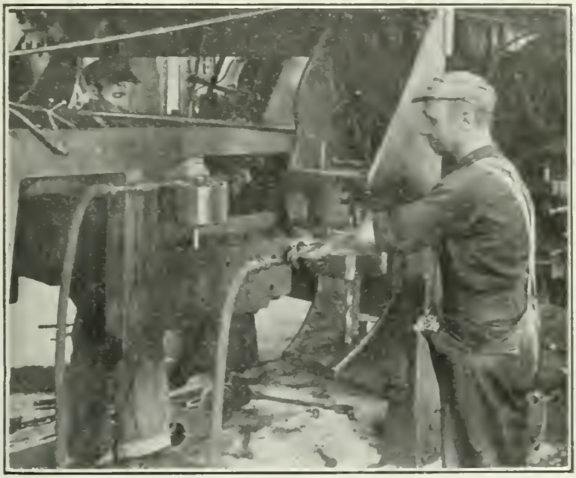
Mr. McKenzie—Who owns it?

Mr. Shedd—I guess it is pretty nearly free.

Mr. McKenzie—What do you mean by its being pretty nearly free?

Mr. Shedd—Well, there wouldn't be much objection to anybody using it for these purposes.

Mr. Albert F. Sickman—I would like to inquire if you know what the efficiency of this compressor is?



WORKING IN CLOSE QUARTERS.

Mr. Shedd—The efficiency has not been measured at this place particularly, but I took part in several experiments as to the efficiency of the plant of Magog, and that ranged from about sixty-two per cent. to a little over seventy per cent. The highest efficiency we obtained was a little over seventy per cent.

Applications of Pneumatic Power in the Machine Shop.

There was a general tendency during the nineteenth century toward the centralization of prime-movers and the operation of all classes of machinery by transmitted power. Among the most common systems of distribution are mechanical (shaft, rope, belt or chain); hydraulic, pneumatic and electric. The mechanical distribution systems are costly to install, and somewhat cumbersome; their practical range is but a few hundred feet.

Hydraulic transmission is objectionable for general use because of the many leaks, and the problem of disposing of the "used" water. Pneumatic transmissions, unless carefully designed, are subject to water-condensation troubles and to invisible leakage. If proper care is exercised to install pipes and joints that do not leak, the practical radius of use (while not usually comparable in length to long-distance electric transmission) is very considerable; and in special cases the system has a number of advantages over electricity. The relative generating, transmitting and operative efficiency, in shops or works installations, or in small plants, is not in favor of electricity; although the costs of piping and wiring, for equal powers, are comparable, the initial costs of generators, *versus* compressors, of electric *versus* air motors, of transformers *versus* reservoirs (not to speak even of switchboards) are greatly to the advantage of the pneumatic equipment.

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* By R. Emerson, in *The Engineering Magazine*

The lack of danger in an air system has been cited—an important feature in tools working in close quarters on metals; and the greater portability of the air tools now on the market compared with the electric contrivances thus far in general use in the United States and in Germany, is a point of advantage that every shop man (and shop men must use the machines) will vouch for. A further underlying advantage is that electricity is used practically to impart rotary motion alone, whereas air has an endless variety of uses. Thus it is that compressed air has found favor in mining, bridge and ship-building, structural steel work, in erecting-shop work; that in a recent large quarry installation it was preferred, though the lines ran two miles from the power plant; that in the early development of Niagara Falls as a power centre, it was proposed to use compressed-air transmission, and that in British Columbia, at Ainsworth on Kootenai Lake, an automatic air-compressing plant is delivering compressed air to miners within a radius of several miles. Modern railroading, as a further instance, with its high-speed and heavy trains, would have been impossible without the air brake.

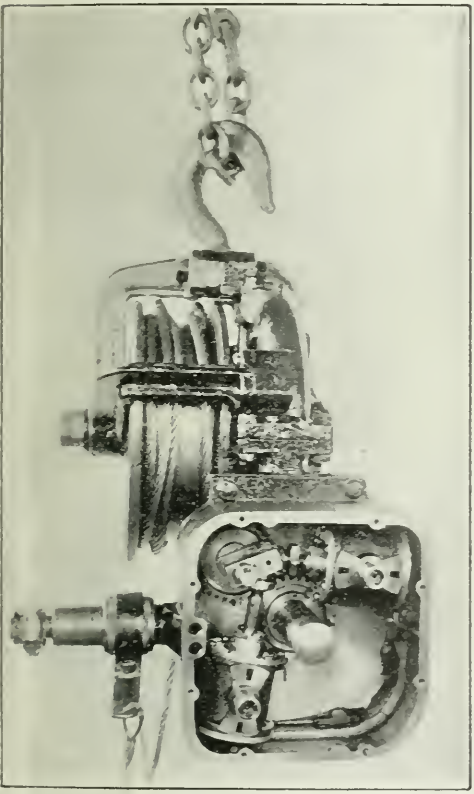
The great variety of uses to which air power can be put has made its development rapid and extensive and its effect on prevailing practices and methods has been so marked as almost to revolutionize every important line of modern engineering. Stone cutters, rock drillers, motors, hammers, yoke riveters, hoists, lifts, presses, carpet cleaners, sand blast, painting machines, conveyors, bolt nippers, jam riveters, flue cutters, holder-ons, air jacks, sand rammers, bell ringers, sand sifters, fire forges, brazing and welding flames—these are a few of the less well-known uses of compressed air.

Pneumatic and electric motors do not "generate" power; they turn into useful work the energy transformed through them. Both electric and pneumatic motors are of such recent development that many practices that ought to be obsolete still prevail, especially in railway shops, where competition does not exert the same stimulus as in commercial shops.

ONE MAN REAMING IN BOILER STEEL.

The shops of the immediate past had a main shaft driven by a Corliss engine. This shaft drove all the machine tools. There was either a mechanical or a hand crane—or none at all—over the erecting or assembling floor. Present practice drives generators direct by high-speed "automatic" engines; takes the current to large 20 or 30-horse-power motors (relegated to the rafters in the shops), each driving a "group" of machines, through main and countershafts, some heavy machines having individual motor-drive; and also installs an air compressor, reservoir and piping, with motors and hammers for use on the floor and outside.

While it is probable that individual and group drive will be retained much as at present, the impending advance in shop betterment with increase of capacity, indicates that many heavy operations will be done by portable tools (whether light electric or air, or the heavier electric-driven machines carried on trucks or transferred by crane) avoiding the effort of moving the mountain to Mohammed. It is this phase of the question that interests us, for it means a transformation not only of work done by hand to work done by power, but also transplanting of work done in the machine shop to work done on the floor, and the savings and economies to be effected will be considerably greater than those obtained through individual or group electric machine-drives—greater even than those obtained by high-speed steels. For example: If it takes 14 hours to set up a job and 6 to do it, of which during less than 3 a high-speed tool is actually cutting, a saving of 10 or 12 hours might be realized by moving a portable tool to the part to be repaired or machined.



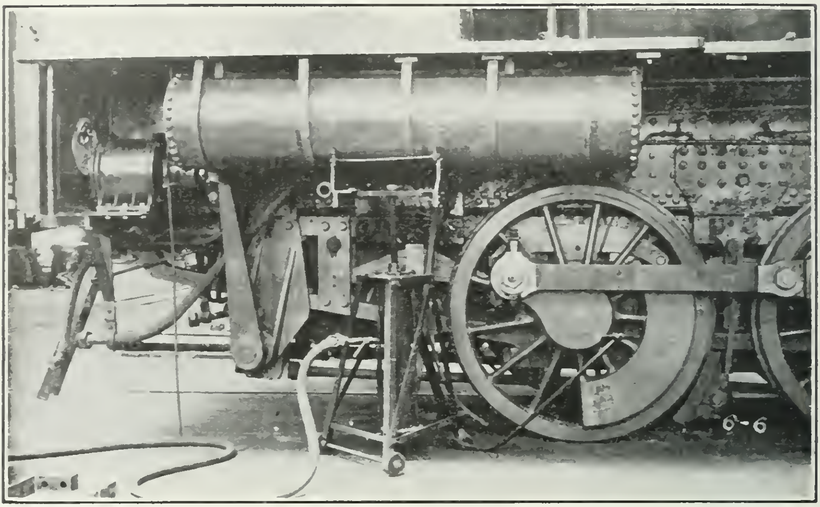
INTERNAL MECHANISM OF AIR HOIST, SHOWING THE SMALL PNEUMATIC ENGINES DRIVING THE WORM OF THE WORM GEAR.

A few years ago (and even in some shops to-day) all drilling, tapping, chipping, calking, riveting, reaming, flue rolling, grinding of joints, cutting, beading, valve-seat facing, ramming, etc., was done entirely by hand, and there was no such thing as an air-lift to handle work for heavy machines: to-day all progressive shops are dependent on air for economical production.

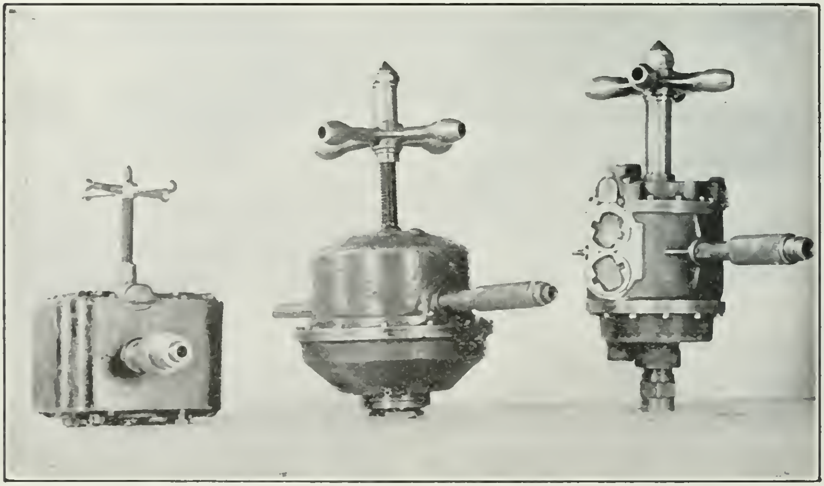
The Evolution of Motors into Modern Types.—Having a general conspectus of the field of work to which portable power-driven tools are applicable, it is interesting to note the recent development and improvement in design of these tools before passing to the consideration of intrinsic merits of modern types.

The earlier motors were heavy and unwieldy compared to those now in use. One of the first was the product of a boiler-shop foreman in a western railway shop. Later, an improved motor, and an air hammer, were developed. A young mechanic, seeing this hammer in operation and realizing its advantages in chipping castings, introduced himself to the inventor, who in a small shop employing four or five men, was making these tools.

The mechanic, who was an able demonstrator, combined with this quality an unusually pleasing personality, great imaginative foresight, organizing ability and unbounded enthusiasm. He agreed to take, and to sell, the entire product of the little shop. Within twelve months the shop output had been increased manifold, and a few years later the inventor was enabled to retire with a large fortune. Great credit must be given to these pioneers through whose efforts this inno-



NEW METHOD OF JACKING AIR RESERVOIR WITH AN AIR-OPERATED DRUM HOIST. IN MARKED CONTRAST TO THE OLD CUMBERSOME BLOCKING-UP.



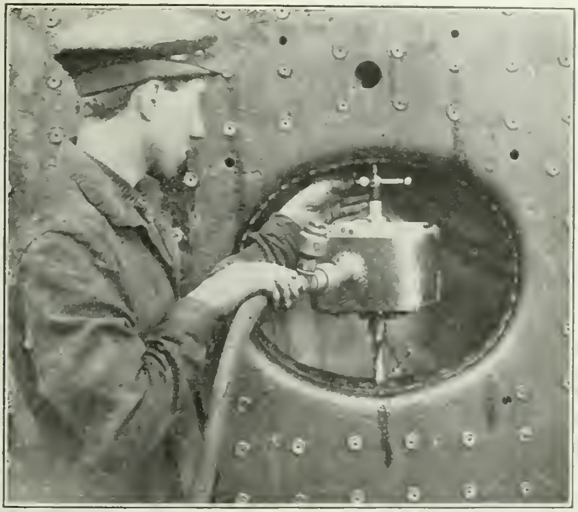
TYPICAL MOTORS, WITH FEED SCREWS EXTENDED.

vation was put into practical and economical use. It is no small achievement to change radically time-honored methods of the mechanical trades in the space of less than a generation, especially when it is realized that the machines in question were far from being perfect when they were first taken hold of by these men.

This brief sketch illustrates the newness of the air-motor as a practical machine, and its rapid extension to many lines of work.

The early motors were unwieldy and inefficient to such an extent that there was great difficulty in persuading men to use them. "Old men," dogs, braces, clamps, had to be rigged up before the machine could be used; but even with a helper (and the weight and vibration of the motor necessitated two men) the men were loath to employ air tools, because of the difficulty in handling. The average man on day work seeks not how quickly, but how easily, to do a job.

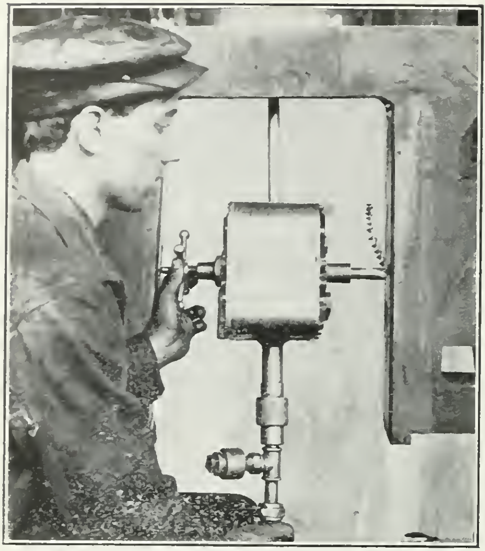
Productive Efficiency in the Shop.—An air tool, however, like all other machinery, is intended as a help to the men and the work, and not as a hindrance, so rival manufacturers have continually had before them the stimulus to make a machine that would not only do the work—do "hand" work in very close quarters—but that would also be easy and convenient to use—that would save, not increase, the man's effort. Realizing the necessity of securing the hearty and willing co-operation of the workers, shop officials have become more critical, have instituted tests of efficiency and power, of durability, and of economy of maintenance in proportion to weight, and these tests have thus reacted on the business of the manufacturers, forcing them by competition to improve their air tools.



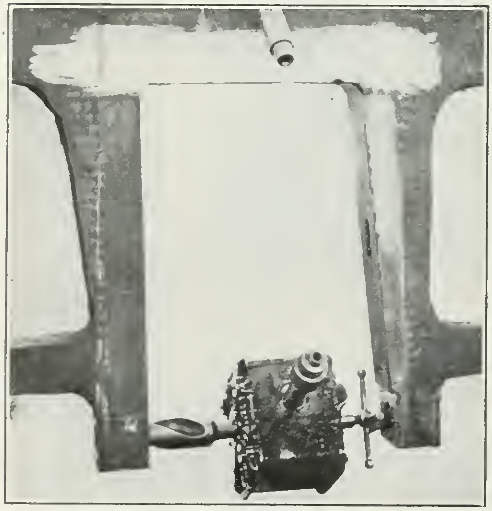
A "HAND" JOB DONE BY AIR.

Drilling in a locomotive fire-door.

As an instance of the interest and influence of users of air tools, a railroad official asked various manufacturers to submit their most efficient and useful machines for test. These and some six of the older type machines were thoroughly tested, at various speeds, under various loads, and with different air pressures. Gauge, meter, scale and revolution readings were taken at half-minute intervals, and endurance tests of half a day were also carried out. From these tests, and from records kept of service of motors and of itemized repairs made to each ma

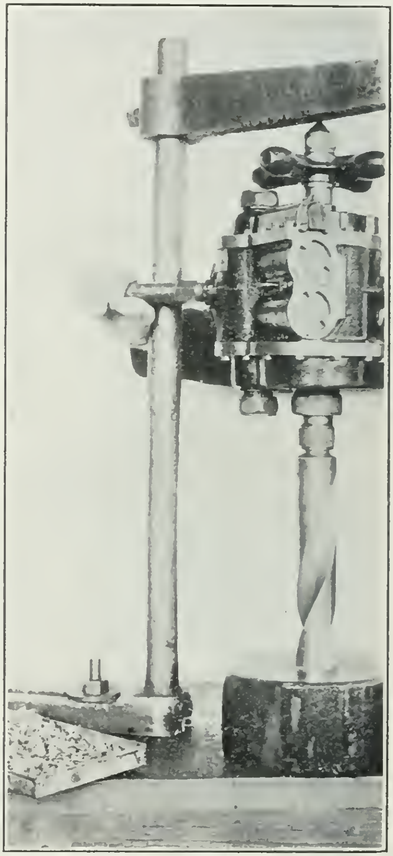


A "HAND" JOB IN NARROW QUARTERS.



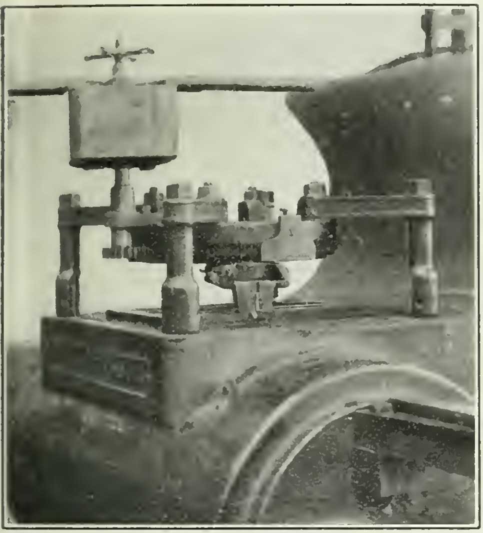
DRILLING FOR PEDESTAL BOLT HOLES IN A LOCOMOTIVE FRAME.

chine, extending over a period of two years, the data in the accompanying diagrams are taken. Consequent upon the tests and their calculated results, orders were placed in several sizes for a number of each of the best machines. These machines, allotted to certain men and gangs in the shops, came at once into general favor, and owing to a rigorous system of inspection and repair (blank forms of the records of which are herewith shown), their efficiency was far higher than had been the case with the older machines, while the repair cost per hours worked fell below that of previous experience.



MODERN HEAVY DRILLING WITH AN "OLD MAN."

Certain of the machines were not assigned to definite gangs, but were for general use. The men who had need of a machine demanded one of the new ones. One make of machine was in particular favor because of its lightness. In fact, there were cases where men had to be disciplined for failing to turn in motors on Saturday night for inspection, because they feared that they might miss getting the same machine Monday morning. Men who would not use a motor previously now began proposing its application to all kinds of jobs, and results in most cases justified in complying with these suggestions.



VALVE-SEAT-FACING ARRANGEMENT.

Hitherto undesirable jobs of reaming and drilling in contracted spaces were made so much easier that they were no longer shunned. The one item of reaming holes alone was cut to less than one quarter the former labor cost, when a heavier type of machine was used. This was due to the fact that the mechanic did not need a helper and could work more quickly and to better advantage.

It will be noted that a number of repair items in the sample record illustrated are quite heavy; and it should be explained that these machines were the total of those "out-of-business" among over one hundred in use in the shops, and that as there was a system of pay in effect rewarding men according to their individual effort, it was considered greater economy to wear out the machine by continual and heavy service than to save the machine at the expense of shop output costs.

Comparative Motor Performance.—There is subjoined an outline drawing showing the general dimensions and sizes of the five principal motors put on the market in the past ten years. These motors have all received extensive use and are the best representatives of the most successful, mechanically and commercially, of the motors of the period mentioned. They are arranged, with one exception, in the order of their appearance on the market and the progress in lightness and compactness is very evident.

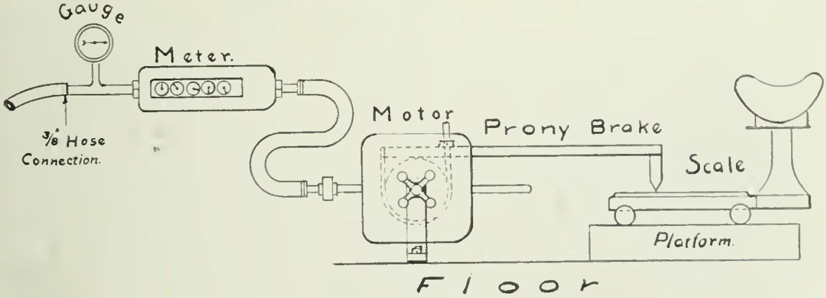
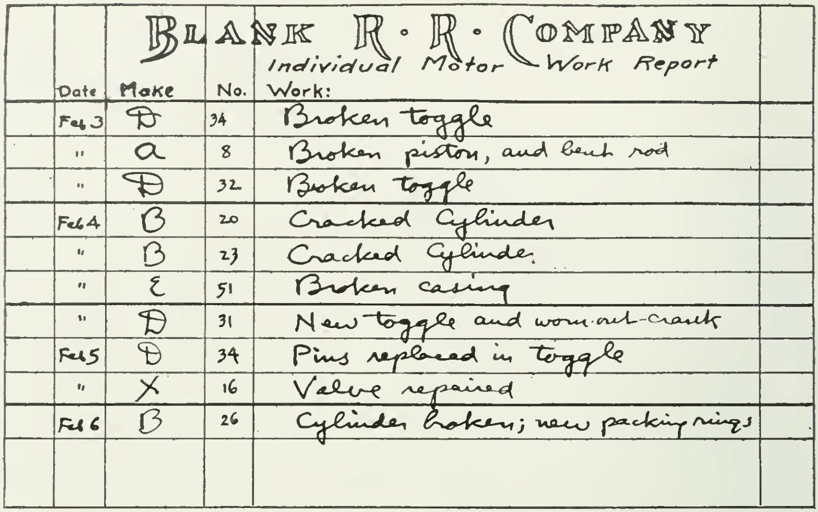


DIAGRAM OF METHOD OF TESTING MOTORS.

Some of the data obtained in the motor test are worthy of attention. The cost of compressed air was determined by a thorough one-week's test of the power plant. In the diagrams the small circles

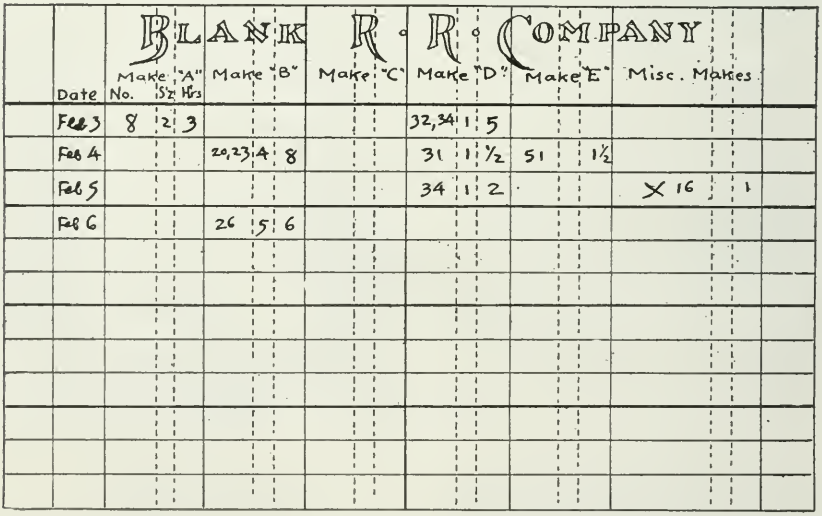


BLANK R·R· COMPANY

Individual Motor Work Report

Date	Make	No.	Work:
Feb 3	D	34	Broken toggle
"	a	8	Broken piston, and bent rod
"	D	32	Broken toggle
Feb 4	B	20	Cracked Cylinder
"	B	23	Cracked Cylinder
"	E	51	Broken casing
"	D	31	New toggle and worn-out-crank
Feb 5	D	34	Pins replaced in toggle
"	X	16	Valve repaired
Feb 6	B	26	Cylinder broken; new packing rings

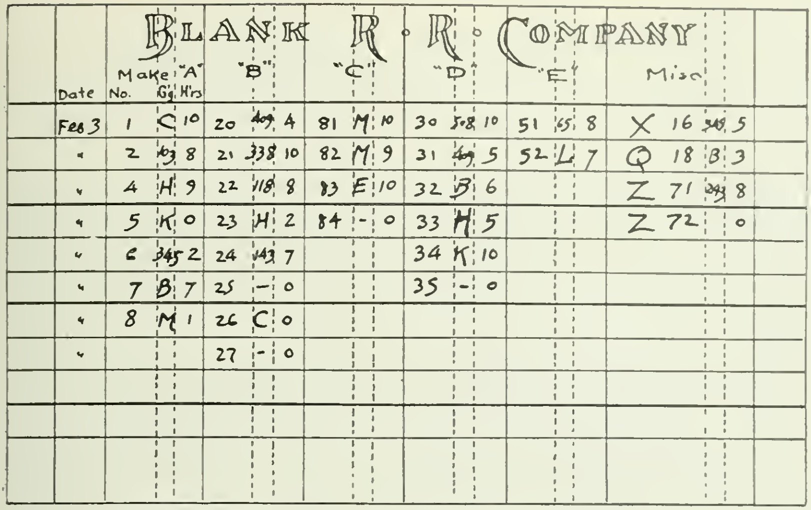
FORM FOR RECORDING AIR-MOTOR REPAIRS.



BLANK R·R· COMPANY

Date	Make "A" No.	Sz	Hrs	Make "B"			Make "C"			Make "D"			Make "E"			Misc. Makes		
Feb 3	8	2	3							32,34	1	5						
Feb 4				20,23	4	8				31	1	½	51		1½			
Feb 5										34	1	2				X 16		1
Feb 6				26	5	6												

FORM FOR RECORDING HOURS OF LABOR, INSPECTION, CLEANING AND REPAIR SPENT UPON EACH MOTOR.



		BLANK R. R. COMPANY															
		Make "A"			"B"			"C"			"D"			"E"		Misc			
	Date	No.	G'g	H'rs															
	Feb 3	1	C	10	20	409	4	81	M	10	30	508	10	51	65	8	X 16	349	5	
	"	2	103	8	21	338	10	82	M	9	31	409	5	52	L	7	Q 18	B	3	
	"	4	H	9	22	118	8	83	E	10	32	B	6				Z 71	243	8	
	"	5	K	0	23	H	2	84	-	0	33	H	5				Z 72		0	
	"	6	345	2	24	143	7				34	K	10							
	"	7	B	7	25	–	0				35	-	0							
	"	8	M	1	26	C	0													
	"				27	-	0													

FORM FOR RECORDING HOURS OF SERVICE OF EACH MOTOR.

"G'g" means gang (or man) using each machine. All the forms shown are 8 by 5 inches, the horizontal lines being spaced ⅓ inch apart; ruled in light blue except the dotted lines, which are red; printed in brown.

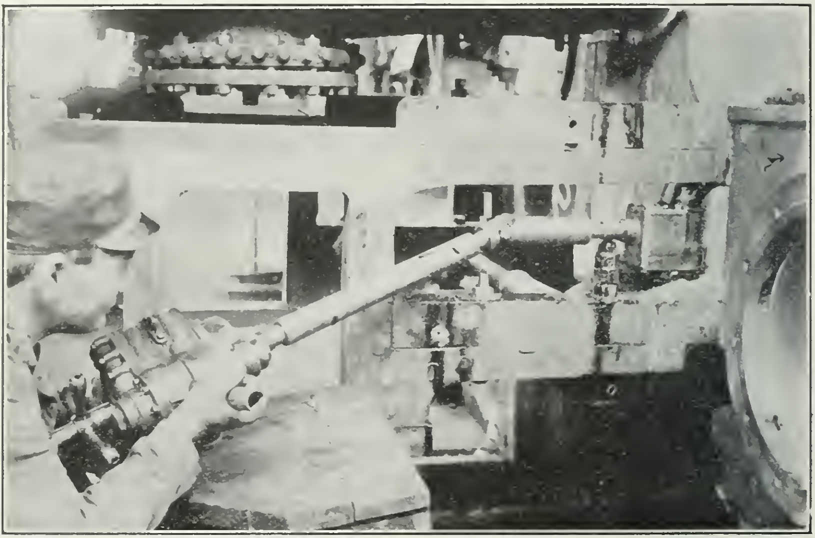
GETTING MOTORS FROM THE TOOL ROOM.

represent the five motors in the order in which they appear in the outline drawing. It will be seen that the net purchase price (in quantity) of these tools has slightly decreased, yet the design has been improved. The efficiency of the motor has increased in every way, also, in a surprising degree—the losses in the older types being due to large leverages and consequent working loose and wearing of parts, and to poor piston fits. It should here be stated, however, that in this series of tests the machines selected were all in good condition, the new ones having been "warmed up" by a few weeks of "active service" and the older machines having been previously put in thorough repair and adjustment, so that each machine might give the best performance of which it was capable.

Referring to the last of the three diagrams, the line representing relative costs of operation per unit of work is most striking.

The earlier casings and parts were heavy and large, to withstand as yet undetermined strains. Little attention was paid to the selection or testing of the materials used in the motor. The tool was driven at a point far away from the crank, and as no provision was made for balancing, the vibration was excessive. The oiling also was unsatisfactory. In the old "wing"-type motors it was difficult to keep the mechanism properly oiled, as the air driving the motor carried out the oil in the exhaust. In the later types, the cranks run in oil, and the air comes in contact with the piston only.

Simplicity of design, compactness, fewness of parts, are the elements that characterize the later types of motor. The strongest motor is not the heaviest; the most powerful is not the largest.

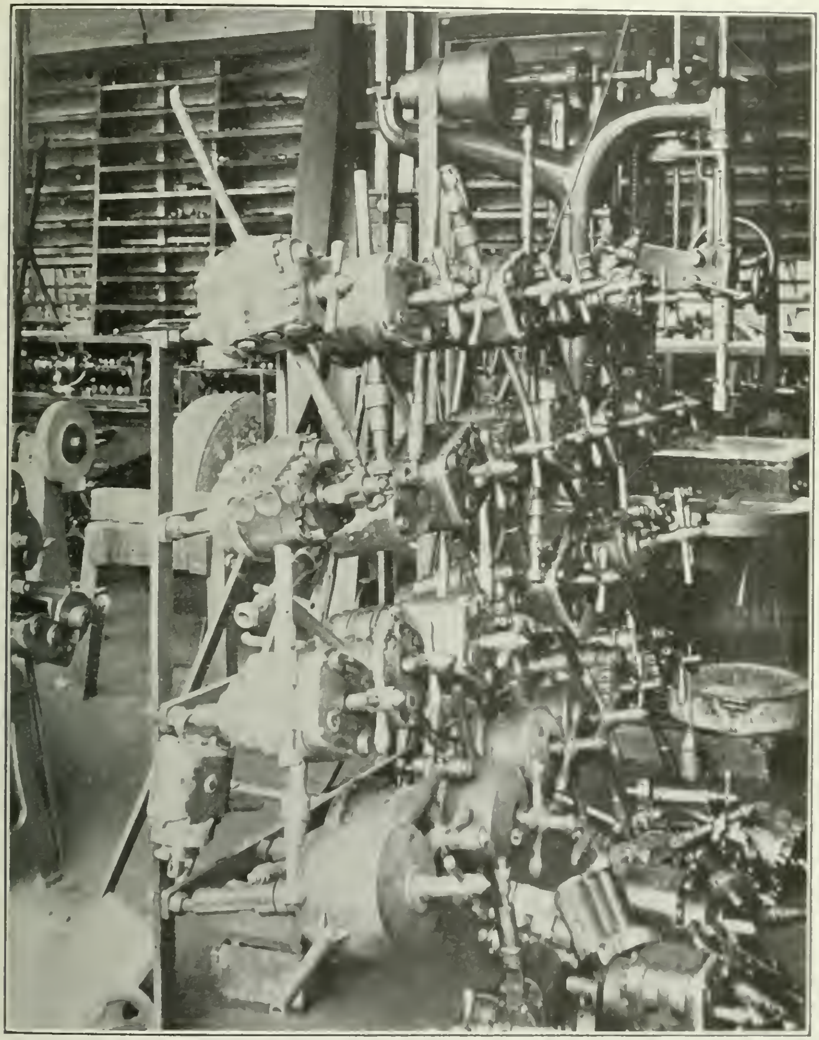


AN "UNDESIRABLE" JOB, MADE EASY BY USE OF ANGLE DEVICES IN CONNECTION WITH AN AIR MOTOR.

In examining into the reasons for the increased economy and compactness of the later types in proportion to power developed, it may be stated that a higher number of revolutions of tool-socket per minute has been one of the factors. In one of the later types a two-speed gear provides for both slow and fast operations and this has been found of great use.

An important point is that in the earlier types, the repair and maintenance costs, as well as the operative costs, were excessively high, and that owing to this condition, the time lost by the machine to productive service was very great. Even under these disadvantages the early machines were able to compete economically with hand labor; and now it is a very favorable sign that the tendency is toward:

Decrease of weight, decrease of first cost, decrease of maintenance cost, decrease of operative cost, increase of effi-



CONVENIENT RACK FOR STORING AIR MOTORS.

Designed by a tool-room machinist.

ciency and economy, increase in applicability to various classes of work, increase of time in service.

While it has been shown that the air motor has well earned an important place in modern industry, and is likely to extend its usefulness, it cannot of course be claimed that the field of power-driven portable tools will be held exclusively by pneumatic tools. There are certain classes and conditions of work for which they are peculiarly adapted, and in general practice, for reasons already mentioned, they will hold their own for long to come over electric and other rivals.

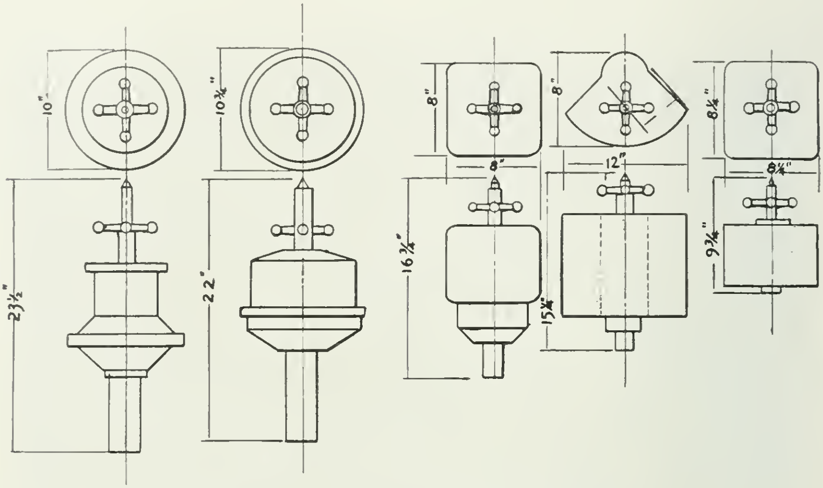


DIAGRAM OF COMPARATIVE SIZES OF MOTORS.

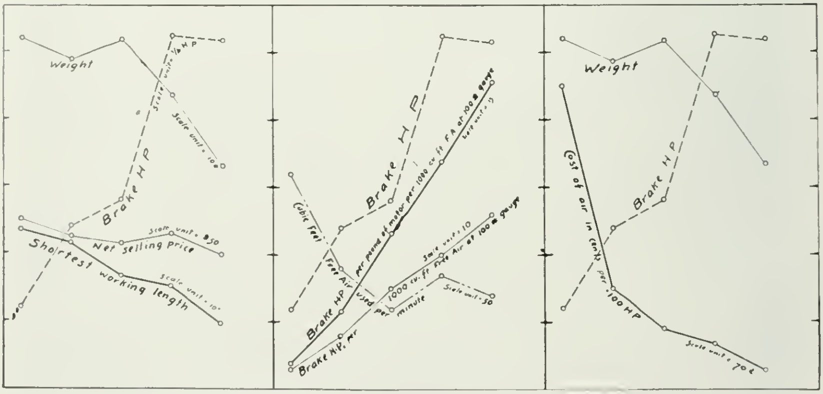
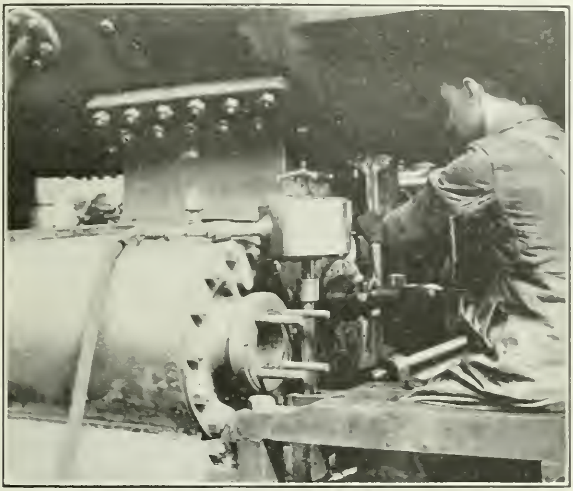


DIAGRAM OF DATA BROUGHT OUT BY TESTS OF AIR MOTORS.

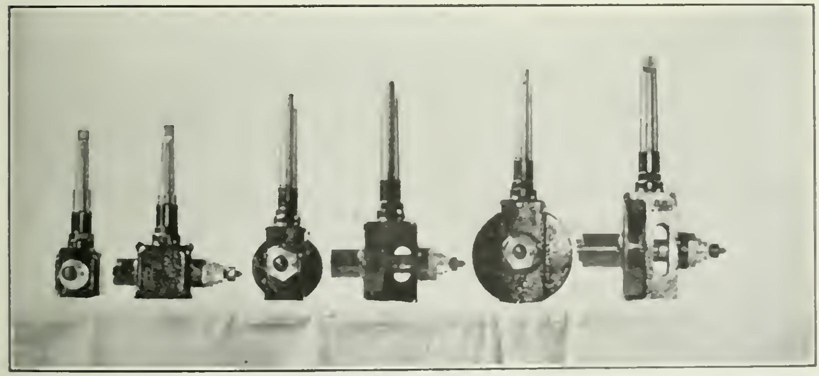
Mean results of three-weeks test upon eight machines, using the method shown in the diagram above.

Portable Electric Motor.—In the past the electric motor has been handicapped in its introduction as a portable tool because of its great weight and comparatively high first cost, proportionate to horse-power developed. For this reason the air motor has held a virtual monopoly of this class of work, even in this "Age of Electricity." Owing to great improvements in design in the past two years, such as air-cooling of coils, etc., the electric portable motor is coming in for serious attention for practical shop-production improvement. An even further reduction of some 10 per cent. in weight is possible by the use of aluminum in armature and field coils.

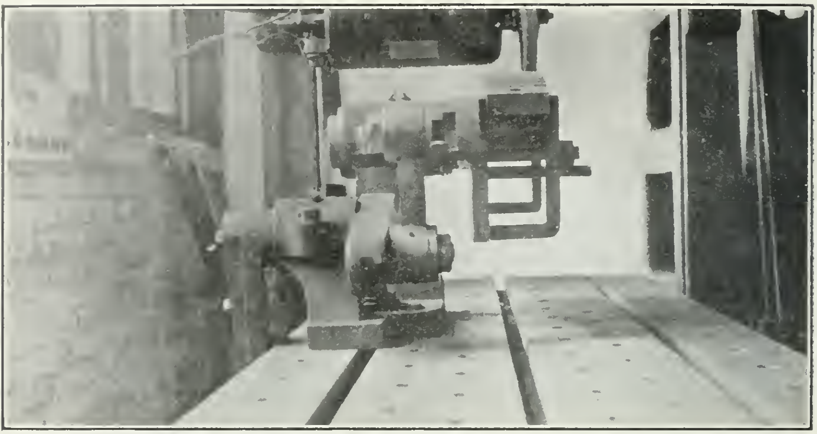
The illustrations show one type of portable electric motor, attached to a planer, grinding links which are given the proper motion by a jig on the bed of the planer. The common cord and Edison plug are used to make connections with great convenience. While these motors are quite light, there is prospect of their being made still more so in future.



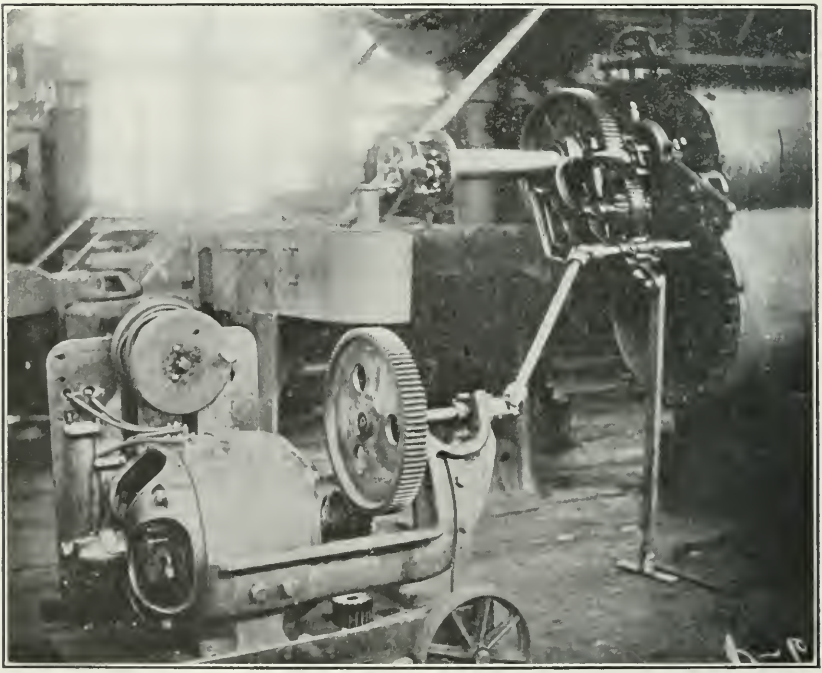
A FORMERLY "UNDESIRABLE" JOB OF REAMING, NOW DONE COMFORTABLY BY AIR TOOLS.



A GROUP OF ANGLE DEVICES FOR USE WITH AIR MOTORS.



PORTABLE ELECTRIC MOTOR CLAMPED TO A PLANER FRAME, ENGAGED IN GRINDING LINKS FOR LOCOMOTIVE.



A TRANSPORTABLE ELECTRIC MOTOR.

Although these motors are too new upon the market to venture any data as to their permanent efficiency compared with air tools of the same capacity, it may be said that they will find a very ready use in shops not at present equipped with an air-compressor, where electric energy is available. Automobile plants, buying their current, will especially find their use economical.

Considerations Governing Purchaser.—Not always having the advantage of special knowledge, or of experience, and lacking time and facilities for testing out before purchase, works managers and superintendents may be in doubt as to the paying value or comparative worth of all the machines and devices drawn to their attention by enterprising supply companies. To such men on the look-out for improved methods, and indeed to all intending purchasers of air-tool equipment, three main considerations are presented:

The tool should be of general adaptability. This is most important, and should largely govern the selection.

It should be maintained and operated at low cost.

Its first cost should not be prohibitive.

As is usually the case, the simplest and most compact motor, of light weight, of few parts, is at once the most adaptable, easiest to maintain and cheapest to make. Fewness of parts calls for less material and less labor per piece. Assembly costs are less, as cheaper labor may be employed. What is here said of manufacturing costs applies equally to repair expense; with fewer parts there is less liability for wear, for lost motion, for breakage; there are fewer "extra" pieces to carry in stock, and there is increased time service.

No one cares to invest in a high-priced tool whose use is limited to a small class of work. I have seen contract shops loaded down with useless and expensive machinery, much of it standing idle the greater part of the time. In many modern railroad shops the machine equipment is ill chosen, this being the main cause of the high repair costs prevalent in the last few years. If, however, one can be assured that the tool to be purchased, whether a heavy machine tool or a portable one, will be in constant service, the investment is well worth while.

The Force of Percussion in Pneumatic Hammers and Drills.

BY C. CHARLES MAISON.

The force of a blow from a hammer in the hand, of a drop press, a pile driver, a hammer, a rock drill, the falling of solid bodies, the water ram in pipes, and the power of projectiles, produce effects deductible from the general laws of dynamics applicable to such work. The power of the hand hammer, which has not yet been classed among the "mechanical powers," without doubt deserves the place of much honor as the most ancient and, in many respects, the most wonderful mechanical power known in its way. We daily see results of its surpassing force, effected without the complication of levers, wheels or wedges, and apparently having some inanimate power superior to and independent of the principles of mechanics as commonly studied. In order to enable any one to make the complete computation of the velocity of a drop hammer in the drop press, a cushioned air hammer, or the monkey pile driver, where the velocity is due to gravity only, the power of impact at the moment of giving the blow may be ascertained from the known height at which the velocity of fall commences. The effect due to cushioning of air and spring hammers will be an acceleration of velocity due to the gross pressure at the starting, and will be described.

The square root of twice the gravity ($\sqrt{64.33}$) multiplied by the square root of the height ($\sqrt{\text{height}}$) in feet; $\sqrt{2g \times h}$, or $8.02 \times \sqrt{h}$ = the velocity in feet per second at the constant of impact of a falling body. Then one-half of the velocity × by the

$$\frac{\text{weight}}{\text{gravity}}\,\frac{v^2}{2} \times \frac{w}{g},$$

or more simply, the height of the fall × by the weight, gives the number of foot pounds due to the fall, and the distance at which the force of the blow is arrested is the measure of the force of percussion or impact. It is as much more than the momentum in foot pounds as the distance of arrest bears to a foot Thus, if at half a foot the impact is twice the foot pounds, of one inch it is 12 times, at 1/4 inch it is 48 times, and at 1-32 inch it is 384 times. This latter arrest represents the impact of hardened surfaces, where the elasticity of the metals largely represents the small movement, at impact, and of which the rebound of a hammer from the face of a hardened anvil represents the reactive effort of the foot pounds due to the momentum of the fall.

A small hammer simply wielded will accomplish that which would otherwise require a direct pressure of several tons. Seeking the cause of its mystic power or energy stored in weight and velocity will account for the varied effects we obtain. In striking a blow with a hammer upon the head of a chisel there are two forces brought into action, viz.: the force of striking and muscular force to increase the velocity, so that at the instant of striking, the hammer may have a velocity of from 20 to 50 feet per second. The effect at this moment is the same as if the final velocity had existed throughout the whole of the stroke. Assuming 32 feet per second as the actual velocity at the moment of impact, then the force will be the same as if the hammer had fallen from a height of the square of the velocity divided by twice the gravity

$$\left(\frac{v^2}{2g}\right) \text{ or } \frac{32^2}{64.33} = 16 \text{ feet.}$$

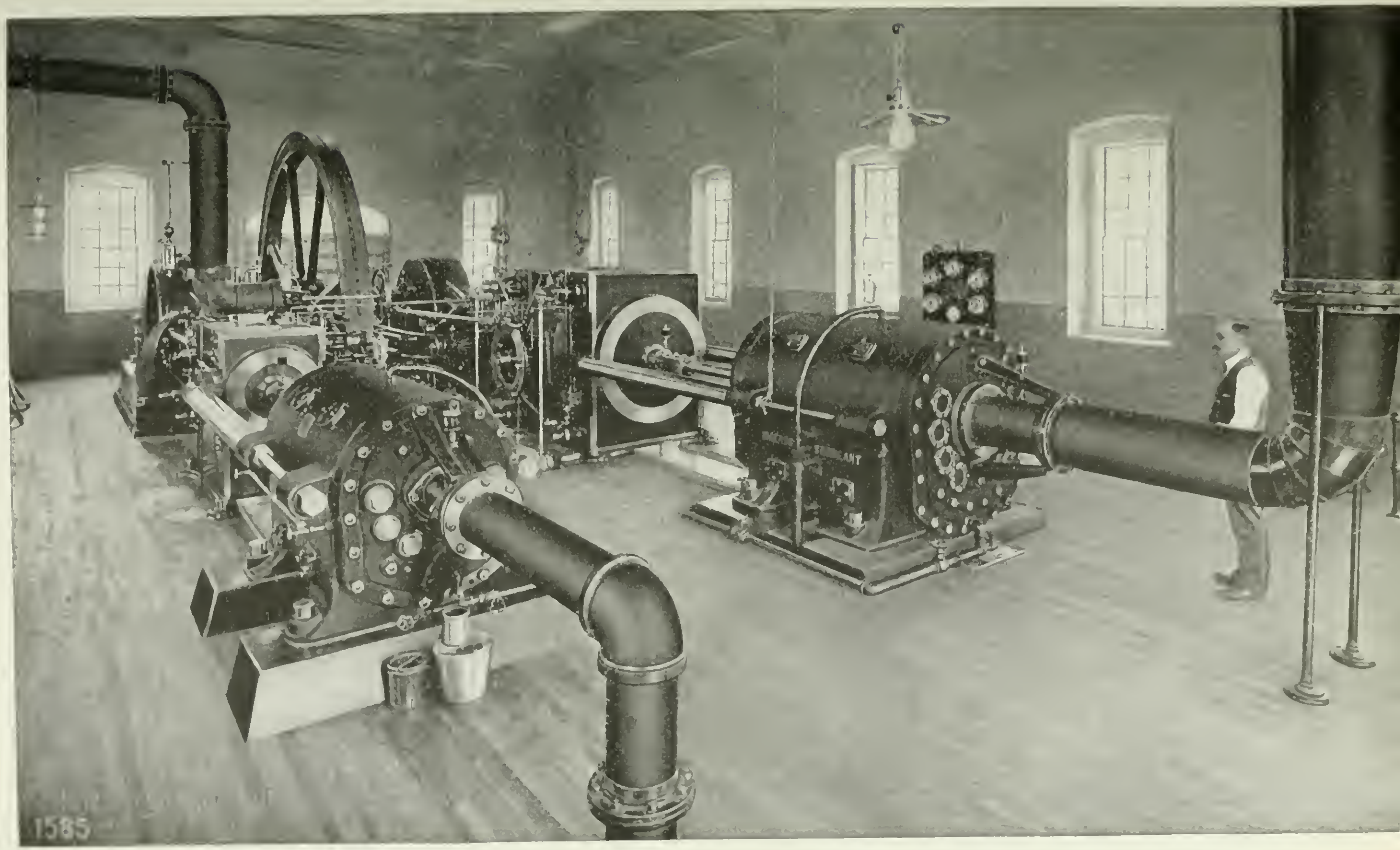
With a hammer weighing two pounds, then, the accumulated work or energy will be 16 × 2 = 32 foot pounds.

Supposing that the face of the hammer moves one-eighth of an inch after touching the head of the chisel before the energy is all absorbed, then the result will approximately be the same as a direct pressure or dead load of $32 \times \frac{12}{\frac{1}{8}} = 3{,}072$ pounds or upward of 1½ net tons; but this is only partially true, however. The hammer may be a self-adjusting, mechanical power; for if the material be harder, so as to give more resistance to the chisel, the cut will not be so great, and therefore the force of percussion will be greater. For instance, if the movement of the chisel, as above stated, had been only one-sixteenth of an inch, the force would have been doubled, or equal to a pressure of 3 tons instead of 1½ tons. But there is a limit to the effect, otherwise the blow would be measured by thousands of tons, until the rigidity of the mass receiving the blow was balanced by the elasticity of the material giving or receiving the blow. This is beautifully illustrated when striking the hardened face of an anvil with a hammer, where nearly the whole force of the blow is returned in the rebound of the hammer.

Compressed Air at the Mohawk Copper Mine, Calumet, Mich.

Copper mining in the Michigan district is expensive. The great depths required, and the low values of the ores entailing the handling of great quantities of rock, make mining costs high and compel close economies to place the mines on a paying basis. This necessity for low operating charges has led to the adoption of high-grade machinery equipments on the Michigan copper mines. Conspicucus among all these equipments are the air compressors, so essential to successful operation. These latter machines are in the great majority of cases of large size and the very highest grade, and the machinery plants of mines in this district, as a rule, represent the highest type of mine power plants. Corliss compressors predominate, owing to their superior steam and fuel economy.

The Mohawk mine, located in the neighborhood of Calumet, Michigan, while one of the newer properties, is one of the most promising mines in that district, and was credited in 1904 with a production of 8,500,000 pounds of refined copper. One of the largest Corliss compressors in the copper district is found on this mine and was built and installed by the Ingersoll-Sergeant Drill Company of New York. The machine is a cross-compound steam, two-stage air compressor having a rated capacity of 5,260 cubic feet of free air per minute at normal speed of 70 revolutions per minute. The steam cylinders are 22 inches and 46 inches in diameter, and are of the latest pattern, with standard Corliss release gear and a steam receiver located in the foundation beneath. Steam pressure is 125 pounds. The gauge on steam receiver indicates a pressure of about 6½ pounds and the engine runs under a vacuum of 25 inches. The exhaust is handled by a jet condenser located with its auxiliaries in the basement below the engine room. Pressure is maintained constant by means of a combined speed and pressure regulator which varies the speed and displacement by changing the cut-off on both steam



POWER HOUSE OF THE MOHAWK COPPER MINING COMPANY AT CALUMET, MICH.

cylinders. Air cylinders are 42¼ and 27¼ inches in diameter, with a stroke of 48 inches. They are completely water jacketed on heads and barrels. The Sergeant piston inlet valve is used on both high and low pressure cylinders and the low pressure intake is connected with a sheet steel intake connection drawing cold clean air through a conduit rising above the roof of the power house. The discharge valves are of positive direct-lift pattern, giving maximum discharge area with a minimum of cylinder clearance. A large horizontal intercooler below the engine-room floor cools the low pressure air discharge to water temperature by contact with surfaces cooled by water circulating through tinned brass tubes.

An independent direct-acting circulating pump in the basement handles the cooling water for cylinder jackets and inter-cooler. Steam pipes for the compressor and auxiliaries enter the basement of the power house through a tunnel leading to the boilers in a separate building. The power house is a stone building with a steel-framed roof. It is well lighted by windows on every side and is spanned by a traveling crane suspended from the roof trusses. The walls are neatly finished and the floor laid in matched lumber, giving one of the most pleasant engine rooms in the copper district. The compressor is set on a solid concrete foundation.

The air pressure carried is 75 pounds, and air is led from the power house to the several shafts on the property. This compressor carries the major part of the load on the Mohawk property. There are, besides this large machine, two other Ingersoll-Sergeant Corliss compressors of an earlier pattern, located in another power house about a half mile distant. These latter machines have a combined capacity of about 3,000 cubic feet of free air per minute and are giving splendid service after years of operation, not only on the Mohawk, but on other work from which they were brought to the copper country. As is to be expected, the greater part of the air volume furnished by these compressors goes to rock drills in the mine, all of which are of Ingersoll-Sergeant and Rand manufacture. The illustration (No. 1585) shows the interior of the main power house and the air end of the large compressor.

Caisson Disease.

A difficulty to be contended with in foundations at great depth is the illness to which men working at high pressure are liable. This illness, in its milder manifestations, takes the form of swellings and tenderness, usually in the joints, and accompanied by severe pain. In fact, this last is such a very marked sympton of the malady that one of the names given it by the men, and which was always used at Newcastle, is the "pains." The longer the time under pressure and the higher the pressure the more severe are the symptoms. Foremen, lock-tenders, and others, who are usually under pressure for a short period at a time, rarely or never suffer except when the victims of a bad cold. In the more severe forms there is paralysis, and sometimes the results are fatal. An explanation of this disease, as a result of his researches and experimental work, was given on the continent by Paul Bert as far back as 1878, and more recently by Drs. Heller, Mager and Von Schrötter, and in our own country by Drs. Leonard Hill and Macleod. The explanation is this—quoting more particularly from Drs. Hill and Macleod—the blood gases increase, according to Dalton's law, under solution. On rapid de-compression gas bubbles escape, arresting circulation and causing pressure on nerves and tissue. The varying gravity of the symptoms is due to the varying seat of the air bubbles. Drs. Hill and Macleod have found that in animals caisson illness can be entirely prevented by slow de-compression, and that cases of illness of the greatest severity following on rapid de-compression from very high pressures can be cured by re-compression if applied soon enough. The explanation of this last is that on re-compression the bubbles go into solution. They therefore advocate slow de-compression, and recommend, as a result of their experiments, that, after a four-hour shift, in + 30 pounds, the period of de-compression should be 30 minutes to one hour. As the only cure they advocate immediate re-compression.

The beneficial effect of re-compression has long been known. At the Forth Bridge men suffering from "bends" were in the habit of spending their Saturday afternoons and Sundays in the working chamber; and at a tunnel under the Hudson River a medical lock, in which the men might be re-compressed, was introduced by Mr. Moir, and was also used by him at the Blackwall Tunnel and by Mr. Davis at Newcastle. Dr. Snell, who was the medical officer appointed by the London County Council to look after the health of the men at the Blackwall Tunnel, in his book, "Compressed Air Illness," while accepting the gas theory of Drs. Hill and Macleod, is of opinion that it is in efficient ventilation that a remedy will be found. It was observed by him that an increase in the percentage of CO_2 was immediately followed by an increase in the number of cases of illness. In the discussion which followed the reading of a paper on the Blackwall Tunnel at the Institution of Civil Engineers, Mr. Moir stated that this had been his experience in tunnel work in America as well as at the Blackwall Tunnel. Dr. Snell is of opinion that slow de-compression, to be of use, must be longer than is practicable, and, therefore, recommends that de-compression should be only moderately slow, and that the percentage of CO_2 should be kept as low as possible. He is of opinion that ventilation at the rate of 12,000 cubic feet per man per minute is the ideal to aim at. The rule for the rate of de-compression at the Blackwall Tunnel was one minute for every 5 pounds above normal. The same rule was observed at Newcastle. As regards re-compression in the medical lock it must be remembered that this, to be most beneficial, must be immediate, and that subsequent de-compression must be extremely slow, say, thirty minutes to one hour from + 30 pounds, as recommended by Drs. Hill and Macleod. Drs. Heller, Mager and Von Schrötter emphasize the importance of the rate of de-compression being constant, and Drs. Hill and Macleod describe, in the account of one of their experiments, the fatal result of hastening de-compression for the last few pounds. An interesting paper has recently been published in the April number of the *Northumberland and Durham Medical Journal,* by Dr. Alfred Parker, dealing with the cases of illness at Newcastle. The subject has also been dealt with by Dr. Oliver, at the Medical Congress, at Oxford, in 1904, and by others.—G. W. M. Boycott, in *The Engineer* (Eng.).

Notes.

AIR compressed by falling water will develop 4,500 horse-power to operate all branches of the Victoria Mine at Rockland, Ontonagon County, Michigan, when the new compressor is completed in a few days.—*Mining Reporter.*

THE Worcester (Mass.) Compressed Air Housecleaning Company has been organized with the following officers: President, Dr. George E. Francis; vice-president, E. G. Connette; treasurer, J. W. Lester; directors, J. W. Lester, John E. Bradley, Francis E. Dewey and Edward G. Connette.

COMPRESSED air employed as motive power in collieries at a distance from the shaft bottom is theoretically less efficient than electric transmission, on account of the thermo-dynamic loss of available energy. There is often a large leakage of air in long pipes. One of the chief advantages arising from the employment of compressed-air plants in coal mines is security from dangerous accidents.—*Engineering & Mining Journal.*

A JOINT meeting of the American Institute of Mining Engineers and of the English Iron and Steel Institute will be held in London, England, on July 23-29. The Lord Mayor of London has consented to act as chairman of the London reception committee and will give a conversazione in the Mansion House on the evening of July 24. A program of the visits and excursions to be made during the meeting will be issued when the arrangements are sufficiently matured.

AN interesting test of the elevator air-cushions installed in the new Hall of Records, New York, by the Standard Safety Air-Cushion Co., recently took place in that building. A car weighing 3,500 pounds and containing two dozen eggs placed on the floor of the car was dropped from the eighth story, and after falling 125 feet with lightning speed, halted safely with only a few of the eggs cracked and none of them displaced enough to mar the pattern on the floor.

THE treatment of minor open spaces in village and city, one of the most interesting problems of civic art to-day, will the subject of an article by Sylvester Baxter in the April *Century*. Among the illustrations, by Jules Guerin, of Mr. Baxter's text, will be pictures of Grand Circle, with the Columbus Monument, and Coenties Slip, New York, the first showing the effectiveness of formal treatment of an open space at the conjunction of important streets; the second the possibilities of securing a restful effect of roominess in a limited area.

THE chief cause of knocking out a machine and of breaking, bending and blunting drills is carelessness and the lack of supervision while starting holes. It is also contended that in actual practice nearly 40 per cent. more work can be done in a given time with the air pressure in underground machine boring in ground of the average hardness found in the Transvaal at 80 pounds instead of at 60 pounds. In West Australia 100 pounds pressure has been kept on the receiver when working in hard quartz. A mistaken desire for economy may induce the miners or the pipe repairer to use worn-out piping and hose for connection, which of course leads to frequent stoppage and to a more or less constant loss of air by leakage.—*The Mining World*.

THE general use of compressed air in railroad boiler shops, it is stated, which had largely aided in advancing boiler-shop practice to the front rank in the railway mechanical departments, is being extended in some shops to include the cleaning of crown bars and crown sheets with a sand blast. It is claimed to do much more satisfactory work than the old way with the hammer and chisel. In a shop where the sand blast is now being used, it formerly took a 17½-cent man ten hours to clean a dozen bars—$1.75 for the lot. With a sand blast a bar is cleaned in 20 to 30 minutes, or in about half the time it took in the old way, and the blast makes a cleaner job. This same shop is said to use the blast for crown-sheet cleaning with satisfactory results.—*Boiler Maker*.

THE publication of a description of a unique engine which has just been built for the South Norwalk Municipal Electric Company has been the basis of much discussion in mechanical circles throughout the State. This new engine involves a new use of a very old and well known principle of physics, viz., that mechanical energy may be transformed into thermic, or heat, energy by compression of the atmosphere. Anyone who has ever used a hand-power air-pump is acquainted with the fact that its barrel quickly becomes hot. It is often said that this is produced by the friction of the pump; but friction has very little to do with it. The heat is produced by the compression of the air within the tube.

The new engine is equipped with an air compressor which compresses the air into a tank at a pressure of 75 atmospheres, or 7' times the pressure of the atmosphere under normal conditions—about 14.72 pounds to the square inch. This is used to give the first stroke of the engine. On the return stroke of the engine the compressor is given back practically all the air lost in the first stroke. This return compresses the air sufficiently to drive from it enough heat to raise the temperature of the cylinder to a temperature of nearly 700 degrees, Fahrenheit. The third stroke is produced by the explosion of crude oil injected into the hot cylinder.

The chief interest in the new engine from a scientific point of view is the method of converting mechanical, or dynamical, energy into heat energy. Theoretically, by the use of this method of air compression practically all attendant losses are avoided, and, therefore, the method promises to come into general use on account of its economy. And it will be interesting to those mechanical geniuses of Connecticut to watch the result of this new experiment.—*Ex*.

THE average depth of a tube well in London is 400 to 500 feet, and the yield obtained varies from 1,000 to 35,000 gallons per hour from single-bore holes. Two artesian wells have recently been sunk at the Prince of Wales's Road Baths, Kentish Town, for the St. Pancras Borough Council, which give a supply of 30,000 gallons per hour. On account of the first of these wells having been reported as yielding no supply, it was on the eve of being abandoned when Messrs. C. Isler & Co. were consulted, and proved a supply of over 15,000 gallons per hour by means of their system of pumping by compressed air. These satisfactory results induced the council to put down an additional well, which is carried to a depth of 480 feet, and to permanently install air-lift pumping machinery. There are, of course, many wells in "inner" London, but this is one of the most favorable sites, there being no others to our knowledge capable of yielding this amount of water. The water is drawn through the chalk, and, being of the greatest purity, is suitable for any purpose, domestic or manufacturing. The same firm has carried out many interesting works of the kind in London, and one at the Metropolitan Electric Supply Company's station at Acton Lane, Willesden Junction, is specially worthy of mention. An artesian well was sunk to a depth of 1,000 feet, chalk being reached at 340 feet from the surface. No supply of water, however, could be obtained. It was then resolved that part of the bore pipes which lined through the Woolwich and Reading beds (sand beds) should be destroyed, and this was accomplished by blasting with specially made gelatine cartridges at a depth of 365 feet. A compressed air lift plant was then put into action, and, by employing other special means and appliances, a supply of 10,600 gallons per hour was obtained.—*London Telegraph.*

It's still cool in the subway for the same reason that it's cool in the streets. During the stinging cold days of winter the comparative warmth of the bore was a blessed comfort to the chilly New Yorker. Little thought then was taken of whether or not the air was vitiated. It was warm, that was enough. But the approach of warmer weather has brought to the fore again the problem of ventilation.

Practically nothing has been done to insure purer air in the subway. The pocket-size electric fans that were installed on tiny ledges at the express stations last summer lived their butterfly life and were either removed or left to rust into innocuous desuetude. The two or three large fly-wheel sort of fan-pumps are covered with dust and look as lonesome, useless and out of date as a French Panama dredge.

These are sights to set the average New Yorker thinking. Surprise has been expressed that the summer will in all probability be allowed to come without any preparation for the ventilation of the underground railroad.

"To begin to install some system under the stress of an aroused and sweating public opinion would be not only farcical, but totally ineffectual," said a well-known engineer to-day. "It seems simply remarkable that New Yorkers never think of their necessities until they're in trouble. All winter they will calmly ride up and down that evil-smelling tunnel without a thought of any future discomfort other than a possible inhalation of steel particles. But as soon as it gets hot and the bore is pretty nearly converted into a huge main for perspiration, they get on their hind legs and kick so almighty hard that the company makes some sort of display of interest, and puts in a teeny-tiny electric fan or two. And I don't blame the company very much, either. I give it credit for knowing human nature."

The subject of subway ventilation is a large one and a puzzler to engineers. Any number of schemes have been suggested, ranging from the electric fan to flushing the tunnel bore with compressed air, much as a pipe is flushed with water. A big difficulty to be overcome is getting the necessary pure air into the passage with as little machinery as possible and without erecting obstructions in the street above. Recently a plan has been talked of that is extremely interesting to transportation men and may go far toward solving the subway problem.

It is nothing less than supplying the subway with highly compressed air, to be gathered into a reservoir at a central point and distributed through pipes to different parts of the bore, as gas is now distributed to given points in a given locality.

Compressed air has only within the past few months been made into a commercial commodity. It is now being sold to consumers for so much a cubic foot, in exactly the same way as gas is sold. George Westinghouse, head of the Westinghouse Company, early in the year made this possible by putting on the market an "air meter," which measures air—to use the same analogy—exactly as gas is measured. The capacity of a meter is 50,000 cubic feet an hour. What new fields of enterprise this invention opens up no one can as yet foretell. But it is expected that compressed air factories—if that term may be used—will shortly be established in this and other large cities for the peddling out of air. It may be that the day of the compressed air carpet-cleaning wagon at the curb is pretty nearly over. The uses of compressed air are many, so that promoters have a large field to work in.

So far the extent of distribution has been no greater than a radius of ten miles. In Belleville, Utah, near Salt Lake City, there is a central compressing plant that supplies air in pipes to the Pittsburg Mining Company, the Fortuna Mining Company, the Ohio Copper Company, the United States Mining Company, and the Honerine Tunnel & Milling Company, the last of which owns and sells the condensed atmosphere to the other four concerns. The air is used principally for supplying the miners. Without it the mines would be almost useless.

It is believed that with the extension of the system many mines that have been abandoned because of great depth will be workable again. So it is that a sort of mining renascence is being looked forward to in certain districts of the West.

The invention of the meter was what made this system of central supply of air feasible and a good business proposition. Every customer—and there may be any number of customers—may pay only for the air he uses. He and his fellow consumers would not be under the necessity of constructing and maintaining their own individual compressing plant, usually an item of much expense.

Should the subway adopt some such method of air distribution as has been mentioned, it would be possible to cool the air as needed, so that some time in the future passengers may get to look upon the subway as something to be enjoyed, rather than a means of quick transportation under trying conditions.—*New York Evening Sun.*

For the conveyance of water, gas, steam or compressed air pipes are made of various materials. In all cases they are subjected to internal pressure, but sometimes the external pressure is of more importance in determining the thickness of metal, for instance in the case of water mains and gas pipes laid below the surface of the streets. These may be subject to the pressure produced by the traffic, or they may be liable to bending strains due to the settlement of the supporting earth in some places. For determining the thickness of metal for a boiler or large pipe subject to internal pressure we employ the following rule: The greatest safe pressure per square inch, multiplied by the diameter in inches, is equal to twice the thickness of metal multiplied by the safe working tensile stress of the material per square inch. Or, pressure+Diameter=2 Thickness× Safe Stress.

This rule makes no allowance for the external and transverse stress mentioned above, nor is any allowance made for the difficulties of casting a pipe of very thin material, nor for the prosity of the cast metal. Thus it is necessary in practice to make these pipes considerably thicker than those given by the above rule, in order to be secure from breakage, or failure, from all causes. The following numerical example will serve to make this matter more clear.

Example.—It is required to find the thickness of cast-iron pipes one foot in diameter, for water main to resist the pressure due to a head of water of 250 feet.

Note.—We may assume the strength of cast iron suitable for this purpose to be eight tons per square inch, and that a head of water equal to 2.304 feet produces a pressure of one pound per square inch.

Now applying the above rule, and taking the safe stress at one-fourth the breaking stress,

Pressure + Diameter = 2 Thickness × Safe Stress

$$\text{Thickness} = \frac{\text{Pressure} \times \text{Diameter}}{2 \times \text{Safe Stress}}$$

$$\text{Thickness} = \frac{\frac{250}{2.304} \times 12''}{\frac{2 \times 8 \times 2240}{4}}$$

$$\text{Thickness} = \frac{250 \times 12}{2 \times 2 \times 2240 \times 2.304}$$

$$\text{Thickness} = \frac{25}{224 \times .768} = .145 \text{ inch}$$

From the above rule the thickness only requires to be a little more than one-eighth inch, but it should be made half an inch, or not less than three-eighths of an inch in order to guard against the risks enumerated above. By using the above rule and taking the safe stress at one-tenth or one-twelfth the breaking strength, good results will be obtained.

Example.—Find the thickness of cast-iron pipes four inches in diameter, suitable for resisting a water pressure of 700 pounds per square inch.

$$\text{Thickness} = \frac{\text{Pressure} \times \text{Diameter}}{2 \times \text{Safe Stress}}$$

$$\text{Thickness} = \frac{700 \times 4}{2 \times 8 \times 2240}$$

$$\text{Thickness} = \frac{\overset{10}{700} \times 4 \times 10}{2 \times 8 \times 2240} = \frac{175}{224}$$

Thickness=.78 inch=25-32 of an inch. When the pipes are made of wrought iron, steel or copper, etc., they are not made so thick as cast-iron ones; chiefly because they are not subjected to the before-mentioned external stresses. The material is of better quality and is not so liable to irregularities of thickness, etc., during the process of making.—*American Cotton Manufacturer.*

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At less than cost, the following imported Mannesmann tubes, designed for storage of compressed air:

12 tubes 20 ft. in length
78 tubes 15 ft. 4½ in. in length.

All designed for a working pressure of 2000 pounds per square inch and tested to 4800 pounds per square inch. All tubes are new and have never been in service.

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U.S. PATENTS GRANTED FEB., 1906.

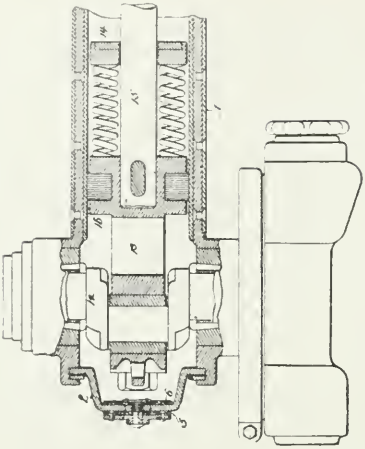
Specially prepared for COMPRESSED AIR.

811,687. AUTOMATIC EMERGENCY AIR-BRAKE-OPERATING DEVICE FOR RAILWAYS. John P. Birmingham, Lexington, Va., assignor to Robert Catlett and Robert Athelstan Marr, Lexington, Va.; William George Mathews, Cliftonforge, Va., and James Easley Edmunds, Don Peters Halsey, and James William Gerow, Lynchburg, Va. Filed July 31, 1905. Serial No. 272,025.

811,690. PNEUMATIC LIFTING MEANS FOR GRAIN-DOORS. Tilghman E. Branson, Belleplaine, Kans., assignor of one-third to Harry Hatfield and one-third to W. S. Foster, Belleplaine, Kans. Filed Mar. 23, 1905. Serial No. 251,668.

811,732. ARMOR FOR PNEUMATIC TIRES. Manson A. Moore, Detroit, Mich., assignor of one-half to Frank H. Bessenger, Detroit, Mich. Filed Feb. 21, 1905. Serial No. 216,767.

811,685. ROCK DRILL. Thomas E. Adams, Cleveland, Ohio. Filed May 27, 1905. Serial No. 262,619.



In a device of the character described, the combination with means for inducing an air-current, of valve mechanism for controlling the direction of said air-current to control the direction of feed of lubricant in the device.

811,723. PNEUMATIC SULKY. Samuel E. Jerald, Waterloo, Iowa. Filed Apr. 26, 1905. Serial No. 257,427.

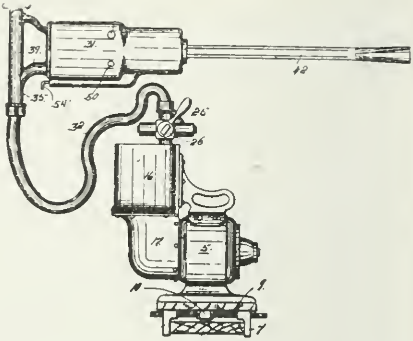
811,736. PNEUMATIC STRAW-STACKER. Joseph W. Nethery, Indianapolis, Ind., assignor to The Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed June 26, 1905. Serial No. 267,025.

811,765. AIR-BRAKE SYSTEM AND AUTOMATIC VALVE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Sept. 16, 1904. Serial No. 224,651.

811,863. AIR-BRAKE. Ernest H. Miller and Charles V. Rote, Lancaster, Pa., assignors of one-third to John W. Holman, Lancaster, Pa. Filed July 21, 1904. Serial No. 217,476.

811,915. PNEUMATIC-TUBE CASH-CARRIER. Daniel S. Hager, Toledo, Ohio. Filed Nov. 9, 1905. Serial No. 286,450.

811,791. MEANS FOR OPERATING DRILLS. Olin S. Proctor, Denver, Colo. Filed Apr. 29, 1905. Serial No. 258,101.



A rock-drill of the class described, including a cylinder, a piston, and means for introducing motive fluid to the cylinder, of a by-pass leading from the drill-cylinder to a point forward of the piston for delivering fluid to the drill-hole, and a check-valve located in said by-pass and adapted to allow fluid to pass therethrough to the drill-hole but arranged to prevent the return of the rock cuttings into the cylinder.

812,151. FLUID-OPERATED ENGINE. Bruno V. Nordberg, Milwaukee, Wis. Original application filed Sept. 18, 1903. Serial No. 173,691. Divided and this application filed Nov. 29, 1904. Serial No. 234,757.

In an engine adapted to deliver a blow, the combination of two cylinders; a piston working in each of said cylinders; a piston-rod common to said pistons; means for admitting steam simultaneously and at the same pressure to the upper face of each of said pistons; and means for admitting steam to the under face of one of said pistons while steam is exhausted from the opposite face of each of said pistons.

812,162. PNEUMATIC TUBE FOR STORE SERVICE. Thomas Bemis, Indianapolis, Ind. Filed Dec. 18, 1905. Serial No. 292,330.

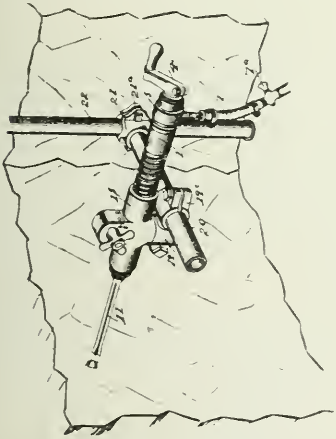
812,228. FLUID-PRESSURE METAL-WORKING MACHINE. Casimir von Philp, Bethlehem, Pa., assignor to The Bethlehem Steel Company, South Bethlehem, Pa., a Corporation of Pennslyvania. Filed Aug. 24, 1904. Serial No. 222,014.

In a fluid-pressure metal-working machine, the combination with a platen, of a fluid-pressure cylinder and plunger mounted in said platen, a bed-plate, a plurality of jacks upon the bed-plate for supporting the work, and means for moving said jacks with relation to said platen, for the purpose set forth.

812,271. PNEUMATIC - DESPATCH - TUBE SYSTEM. John S. Jacques, Dorchester, Mass. Filed May 24, 1905. Serial No. 261,963.

812,375. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Filed Aug. 7, 1905. Serial No. 273,125.

In an apparatus of the class described, a supporting-casing, a drilling mechanism supported therein and feedable therethrough, means cooperatively connecting the supporting-casing and the drilling mechanism to permit the drilling mechanism being fed forward at each forward impulse of the drill-hammer, and means whereby said drilling mechanism can be bodily withdrawn from said supporting-casing, substantially as shown and described.



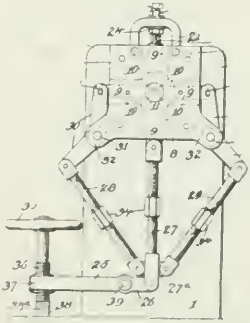
An apparatus of the class described, comprising drilling mechanism consisting of an elongated tubular casing having an external thread, a tubular hammer-barrel fitted within said casing, a drill-chuck within said hammer-barrel at its forward end, a closure-plug within said hammer-barrel at its rearward end, inlet-apertures connecting with the interior of the hammer-barrel and the interior of the drill-casing, exhaust-ports for the hammer-barrel, a reciprocating hammer within the hammer-barrel, means for admitting compressed air into the drill-casing, a handle member secured to the drill-casing whereby the same can be turned on its longitudinal axis, a tubular supporting-casing having a bore for receiving the drill-casing, a worm-gear mounted in said supporting-casing and adapted to mesh with the threads on the drill-casing, a hand-wheel for turning the worm-gear, said worm-gear and said drill-casing being arranged to allow the drill-casing to be automatically fed forward by the forward movements of the hammer, while simultaneously permitting the drill-casing to be turned on its longitudinal axis by means of the handle, and means for mounting said supporting-casing to permit adjustment of the drilling mechanism with the longitudinal axis of the drill-casing at any angle substantially as shown and described.

812,423. MEANS TO REPLENISH THE AIR-CHAMBERS OF PUMPS WITH AIR. Henry T. Hazard, Los Angeles, Cal., assignor of one-half to Albert Hoberecht, Ensada, Mexico. Filed Oct. 5, 1904. Serial No. 227,278.

Means to replenish the air-chamber of a pump with air, comprising a main air-chamber and a supplementary chamber below the same, a partition therebetween, a port in said partition and a port in the bottom of the supplementary chamber and valvular means to alternately open and close said ports.

812,431. AIR-VALVE. William J. Rice, Mason City, Iowa. Filed Nov. 7, 1904. Renewed July 22, 1905. Serial No. 270,897.

812,570. APPARATUS FOR SHARPENING ROCK-DRILLING MACHINE BITS. Joseph A. G. Kirsten, Randfontein, Transvaal. Filed Mar. 15, 1905. Serial No. 230,151.

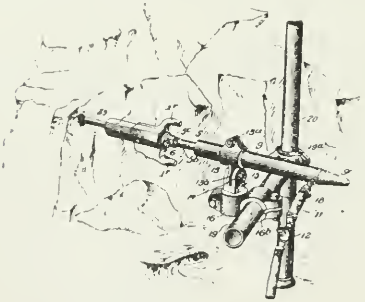


In apparatus for sharpening rock drilling bits, a main vertical plate, a second vertical plate fixed thereto and having a central aperture and vertical and horizontal guideways radiating from said aperture, die-carriers in said guideways, dies attached to said carriers, a device for adjustably supporting the top vertical die, levers pivoted to the second plate and connected to the horizontal die-carriers, a lever pivoted to the main plate and yieldingly connected with the bottom vertical die-carrier and with the levers operating the horizontal die-carriers, and means for operating the lever pivoted to the main plate.

812,697. AIR-BRAKE APPARATUS. Augustus A. St. Clair, Indianapolis, Ind. Filed Aug. 12, 1905. Serial No. 273,871.

812,752. DISTRIBUTING-VALVE FOR AIR-BRAKES. Georg Knorr, Britz, near Berlin, Germany. Filed July 11, 1904. Serial No. 216,171.

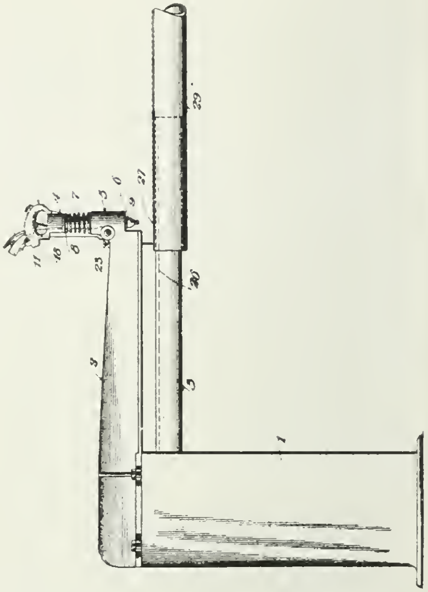
812,774. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Original application filed Aug. 12, 1905, Serial No. 273,930. Divided and this application filed Sept. 2, 1905. Serial No. 276,876.



In an apparatus of the class described, the combination with a drill-casing and a drill carried thereby, a clamp for receiving said drill-casing, said clamp including means whereby the drill-casing can be swung clear of the drill and back again without changing the alinement of the drill-casing substantially as shown and described.

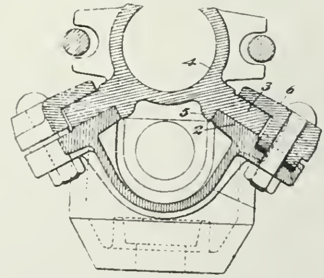
812,792. PNEUMATIC - DESPATCH - TUBE SYSTEM. John S. Jacques, Dorchester, Mass. Original application filed May 24, 1905, Serial No. 261,963. Divided and this application filed Dec. 23, 1905. Serial No. 293,092.

812,787. PNEUMATIC RIVETING-MACHINE. John R. French, Los Angeles, Cal. Filed Feb. 1, 1904. Serial No. 191,443.



In a pneumatic riveting machine, a support, a riveter movably mounted therein and provided with valve mechanism, means for moving the riveter, and a connector from the valve mechanism to said means so arranged as to be operable to control the valve at any position of the riveter.

813,041. ROCK-DRILL. David C. Demarest, Angels Camp, Cal. Filed May 4, 1905. Serial No. 258,845.

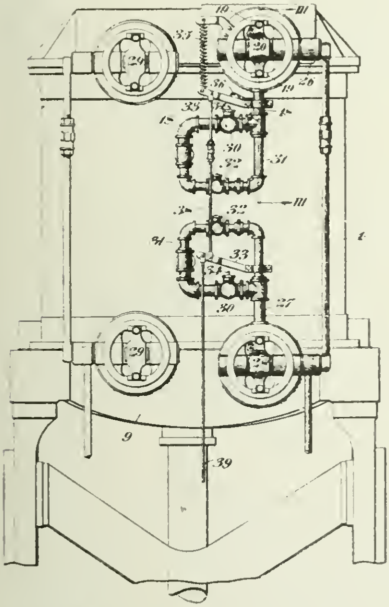


In a rock-drilling machine the combination of a shell and a cylinder supported thereon, one of said parts having lugs and the other part having seats for said lugs, and means to clamp the cylinder to the shell, said means including bolts passing through the caps and shell, said shell having counterbores, and said caps having bosses fitting said counterbores.

812,883. DOOR-OPERATED AIR-PUMP FOR ATOMIZERS. William H. Rose, Baltimore, Md. Filed Oct. 30, 1905. Serial No. 285,060.

812,989. POWER-BRAKE MECHANISM. Curtis B. Goode, Boston, Mass. Filed Jan. 4, 1905. Renewed Nov. 11, 1905. Serial No. 286,836.

813,064. CONTROLLING MECHANISM FOR BLOWING-ENGINES. Johnson V. Symons, Johnstown, Pa. Filed May 18, 1905. Serial No. 260,935.



In a blowing-engine, the combination with the air-cylinder and the main shaft, of an outlet-valve for the air-cylinder, an actuating-cylinder for said valve, a passage-way connecting said actuating-cylinder with the air-cylinder, a controlling-valve in said passage-way, a by-pass for said controlling-valve, a check-valve in said by-pass, a lever for closing said controlling-valve; a ratchet-clutch on the main shaft operative only when the engine is run backward, a rock-shaft connected with 'said clutch, a rocker-arm on said rock-shaft, a friction-clutch interposed between said rocker-arm and said rock-shaft, a connection between said rocker-arm and said lever and means for returning said lever and its operating mechanism to their normal position when inoperative.

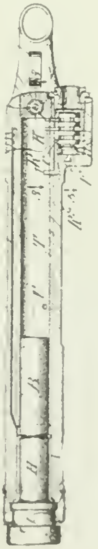
813,073. PNEUMATIC GRAIN-ELEVATOR. William C. Allen, Gurley, Ala. Filed May 10, 1905. Serial No. 259,714.

813,075. GENERATOR OF FLUID-PRESSURE. Adrien Baudin, Paris, France. Filed Aug. 5, 1903. Serial No. 168,325.

A fluid-pressure generator comprising a chamber containing a quantity of aqueous material, a pump for drawing air through said material, a chamber into which the cooled and moistened air is delivered, and means for heating said last-named chamber.

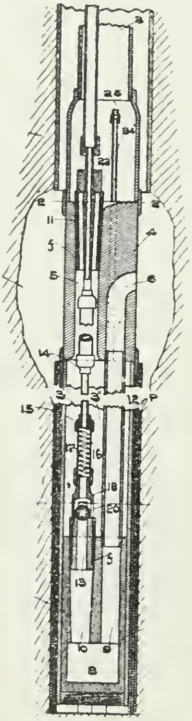
813,090. AIR-BRAKE MECHANISM. Alva L. Goodknight, Council Bluffs, Iowa. Filed Sept. 6, 1905. Serial No. 277,228.

813,109. PNEUMATIC HAMMER. Reinhold A. Norling, Aurora, Ill., assignor to Aurora Automatic Machinery Company, Aurora, Ill., a Corporation of Illinois. Filed Feb. 17, 1905. Serial No. 246,146.



The combination of a cylinder having an integral handle on its inner end and a bore which extends through its said inner end, a plunger in said cylinder, a controlling-valve casing integral with and extending laterally from the inner end of the cylinder and having a bore which is closed at one end by the integral, outer end wall of the casing and opens at its other end through the inner end of the casing, a valve-piston in the said valve-casing having its central axis parallel with the cylinder, and separate closures for the inner end of the bore of the cylinder and for the bore of the valve-casing.

813,322. DEVICE FOR RAISING LIQUIDS FROM WELLS. William Richards, Mayburg, Pa. Filed Feb. 3, 1904. Serial No. 191,841.



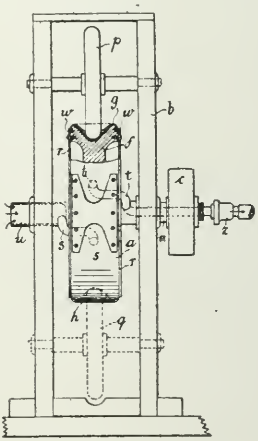
In an improved device for raising liquids from wells, a reservoir located below the producing strata, a bridge located at the upper end of said reservoir, a valve located in said bridge, there being an air-passage and an oil-passage formed within the body of said valve.

813,305. SUPPLY AND EXHAUST VALVE MECHANISM FOR MOTORS. Wilber H. Johnson, Cumberland, Md. Filed July 5, 1902. Serial No. 114,436.

In a motor, the combination of a motor, a piston operating therein, a fluid-supply pipe, a controlling-valve in said pipe, reciprocating means governed by the piston for periodically operating said valve, an exhaust-valve in the supply-pipe controlling the exhaust of spent fluid from the motor to the atmosphere, and means of which the first-mentioned means form a part for operating the exhaust-valve alternately with the said controlling-valve.

813,390. AIR-BRAKE COUPLING. Heraclitus H. Sartain, Burroughs Cove, Tenn. Filed June 17, 1903. Serial No. 161,881.

813,443. COMPRESSOR. Hans Mikorey, Schoneberg, near Berlin, Germany, assignor to The Firm of W. Graaff & Company Gesellschaft mit Beschrankter Haftung, Berlin, Germany. Filed May 10, 1905. Serial No. 259,797.



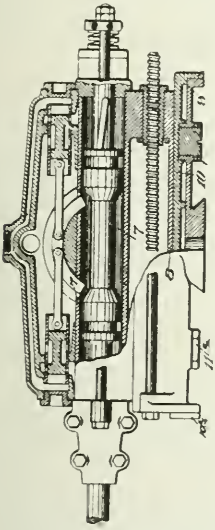
A compressor comprising a wheel having a groove on its periphery, a membrane formed of rubber stretched across said groove so as to form an annular chamber, means for holding said membrane at one point permanently pressed against the bottom of the chamber, an inlet-pipe entering said chamber on one side of said means, an outlet-pipe on the other side thereof and a roller of less thickness than the wheel engaging the membrane so as to force it against the bottom of the groove.

813,747. AUTOMATIC AIR-BRAKE COUPLING. Arthur H. Skillings, Brooklyn, N. Y. Filed Dec. 15, 1904. Serial No. 236,924.

813,636. PNEUMATIC - DESPATCH - TUBE APPARATUS. Edmond A. Fordyce, Boston, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed Mar. 24, 1905. Serial No. 251,770.

813,691. BRAKE AND TRACK-SANDING MECHANISM. Murry A. De France, Newark, Ohio, assignor of one-fourth to Albert H. Sisson, one-fourth to Charles E. Krebs, and one-fourth to W. Bernard Wingerter, Newark, Ohio. Filed Sept. 7, 1905. Serial No. 277,378.

813,823. ROCK-DRILL. Edward A. Rix, San Francisco, Cal. Filed Aug. 16, 1905. Serial No. 274,487.

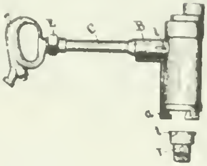


The combination in a rock-drill, of a cylinder, having a slide fixed to and projecting from its bottom, a shell within which said slide is movable, the bottom of said slide and the bottom of the guide being spaced from each other, and means operable in said space between said bottoms and adjustable in one direction to compensate for wear between the bottom and also the sides of said guide.

813,900. PROTECTING DEVICE FOR PNEUMATIC TIRES. Emile Lapisse, Elbeuf, France. Filed Sept. 2, 1905. Serial No. 276,828.

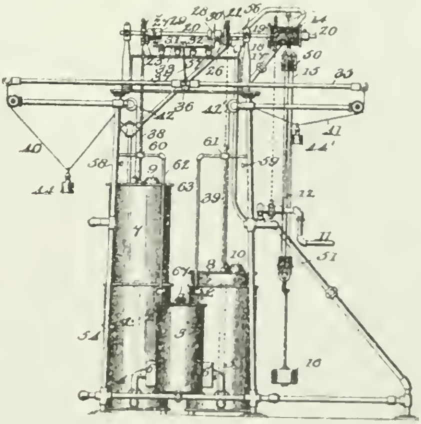
813,934. PROTECTIVE COVER FOR PNEUMATIC TIRES. Josef Albers, Aix-la-Chapelle, Germany. Filed Apr. 7, 1905. Serial No. 254,415.

813,921. PNEUMATIC DOLLY. James A. Shepard, Montour Falls, N. Y., assignor to The General Pneumatic Tool Company, Montour Falls, N. Y. Filed May 6, 1903. Serial No. 155,866.



In a dolly, the combination of a barrel, a piston projecting therefrom, a die set eccentrically upon the end of the piston, a handle projecting from one side of the barrel, a longitudinal slot on the piston, a guiding member in the barrel in engagement therewith, whereby the piston is held from rotation with freedom to reciprocate and the die is held in fixed relation to the handle, and means for admitting fluid under pressure behind the piston.

813,982. SELF-REGULATING AIR-PUMP. Maximilian Loewenstein, Brussels, Belgium, assignor of two-thirds to Jonas Stork, Brussels, Belgium, and Maurice Kind, New York, N. Y. Filed Apr. 14, 1905. Serial No. 255,617.



In a self-regulating air-pump, the combination of a series of bells, means for lifting said bells alternately and automatically, and connections whereby the fall of one bell immediately causes it to be lifted and at the same time releases another bell, substantially as described.

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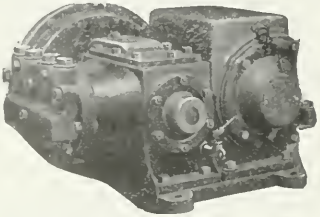

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JUNE, 1906.

THE COMPARATIVE MERITS OF AIR AND ELECTRIC DRILLS.

Written for COMPRESSED AIR

By

Granville E. Palmer

Invention has probably never won fewer and poorer rewards, in proportion to the talent expended, than those received by the designers of Electric Drills; and as the progress of the art during the past twenty years is analyzed, it seems to the writer that the difficulties presented to the designers of this form of apparatus are insurmountable.

The Air Drill seems to occupy a very secure position with regard to its retention as a standard form of apparatus; and it is quite remarkable that as a labor-saving device one of the most inefficient pieces of apparatus ever designed should have proved the most economical in its particular field.

Drilling holes in rock is an operation in which an exhibition of bull strength and awkwardness is desirable, and this feature the air drill seems to possess to a commercially marketable degree, to the exclusion of all other types of power drills. A jarring hammer blow, transmitted to a cutting edge, is the way of all ways for putting in rock holes of moderate depth; and for this class of work, tools driven directly by air or steam are practically ideal, as all of the parts of the reciprocative piston that are liable to damage are easily protected from mechanical injury, and so enclosed in a chamber of elastic and compressible gas that no damage results to them, even when the drill is instantly stopped by sticking in the hole—a not infrequent occurrence. Of course the electric drill, with its short, rapid stroke, cuts a cleaner and straighter hole than the air drill; but it does stick and stop short, with damaging results.

The particular advantages claimed for the electric over the air are low first cost of plant, ease of installation, and great economy of power,—and every one of these claims are true; but when the high cost of maintenance and time lost incident to break-downs are considered, the above claims sink into insignificance—particularly when the continuous operation of the entire mine depends more upon the reliability of the rock-drilling apparatus than on perhaps any other operation.

The reasons that the air and steam drills are a success, as above noted, are that the essential delicate parts are protected from jar, and that no injury to the apparatus occurs when the drill is stopped by a "sticky hole." The reason why the electric drill has proved a failure is because it is impossible to properly protect the motor from jar, and at the same time properly transmit and transform its rotary motion to the reciprocatory stroke necessary to operate the drill steel.

No form of insulation has yet been devised that will stand up under the continued jar of the drill body for any appreciable length of time; and though the results of experimental work have led several designers to believe that they had found a satisfactory form of insulation, the most successful types of apparatus have the drill proper connected with its motor by a flexible or semi-flexible shaft.

With the motor removed from the drill body, the insulation difficulties are overcome, and the transmission of the power from the revolving armature to the reciprocating draw bar, and from it to the chuck and ratchet bar is the last point to consider. As the travel of the draw bar, driven by a crank shaft and internal cam, must have definite limits of motion, and as the connection between the draw and chuck bars must be sufficiently flexible to permit the draw bar's continued operation when the chuck bar is held stationary by reason of the drill sticking in the hole, and at the same time be sufficiently rigid to permit of the chuck bar striking a blow representing a hundred or more foot pounds of energy under normal conditions, an exceedingly efficient spring transmission is necessary. Though wonderful things have been accomplished in spring manufacture, it does not seem that the art has reached the stage where the above results can be obtained in regular practice.

The usual reason for the installation of power drills in place of hand steel is to permit of a more rapid advance in this branch of the work, so that it may keep step with other operations, and the use of apparatus that does not accomplish this result—even though it does perform the operation of drilling holes with somewhat greater economy—is a step backward. I think that the following table, compiled from a recent comparative test between two Adams Electric Drills (which certainly are equal, if not superior to any other electric drills on the market) and two old 2¾" Air Drills, operating at eighty pounds pressure at sea level, shows conclusively that the value of electric apparatus for work of this character is questionable.

Work done on black diabase about 7½° during fifty-three consecutive ten-hour shifts.

	Air Drill	Elec. Drill
Actual hours drilling....	317	100
Actual feet drilled......	1,279	253
Average feet per hour..	4	2.55
Times stopped for repairs	0	17

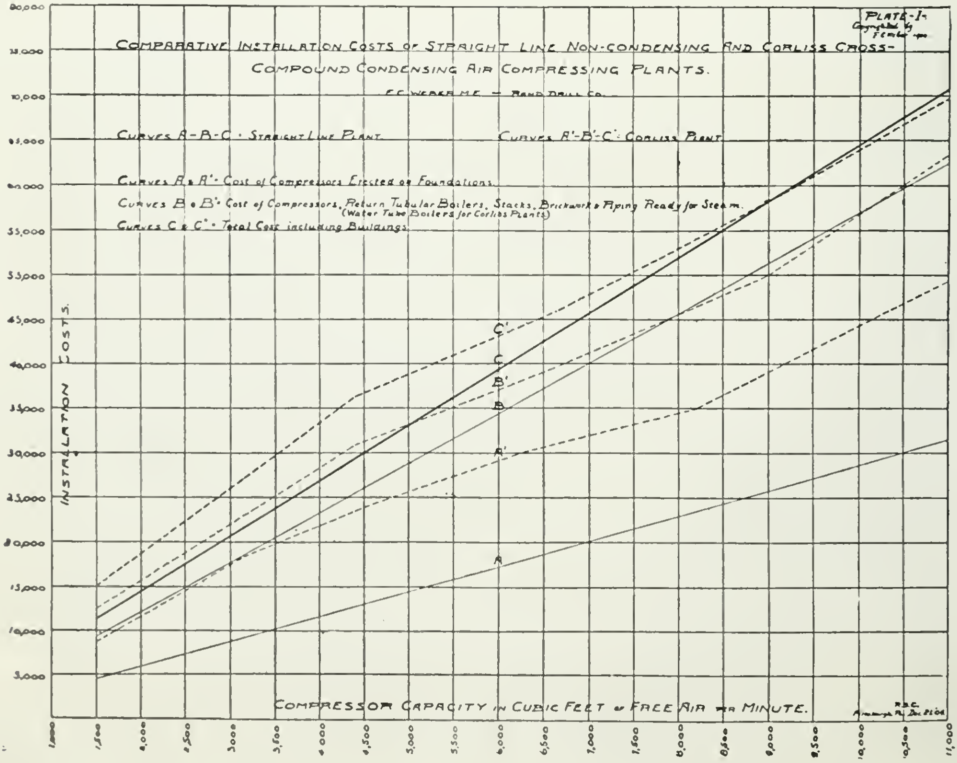
ECONOMY IN THE OPERATION OF COAL MINE POWER PLANTS

BY F. C. WEBER, M. E.

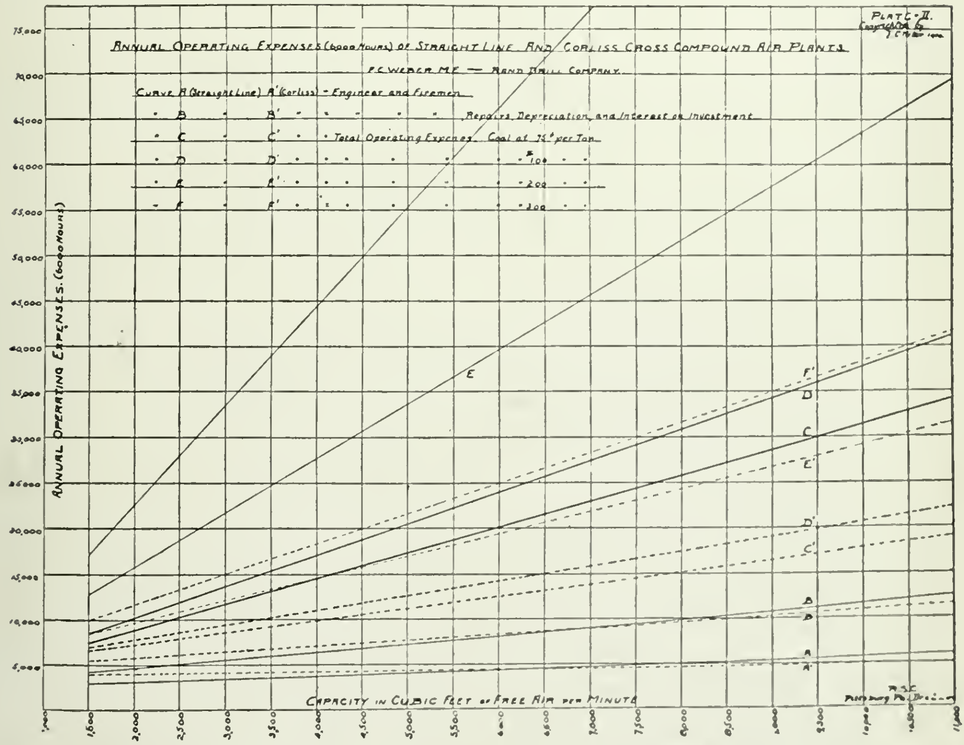
The advantages of the Corliss type of steam-engine over that of any other type of slow speed engine have been universally recognized by the engineering world for many years, and when used as the "power end" of an air compressor it is generally recognized that this combination produces the highest type of air compressor. This is especially true of the larger sizes of compressors.

This fact has long been taken advantage of in the mining districts of South Africa, Michigan, and many others, where fuel cost is an important item. Many of the mines at first acquired a number of small compressors to supply their different operations, which they replaced with larger Corliss compressors, as the total capacity warranted such a change. In many new mines to-day Corliss compressors are the only type considered from the start.

The more prominent coal mines are now beginning to place the proper value on this type of compressor, for the oldtime heresy that

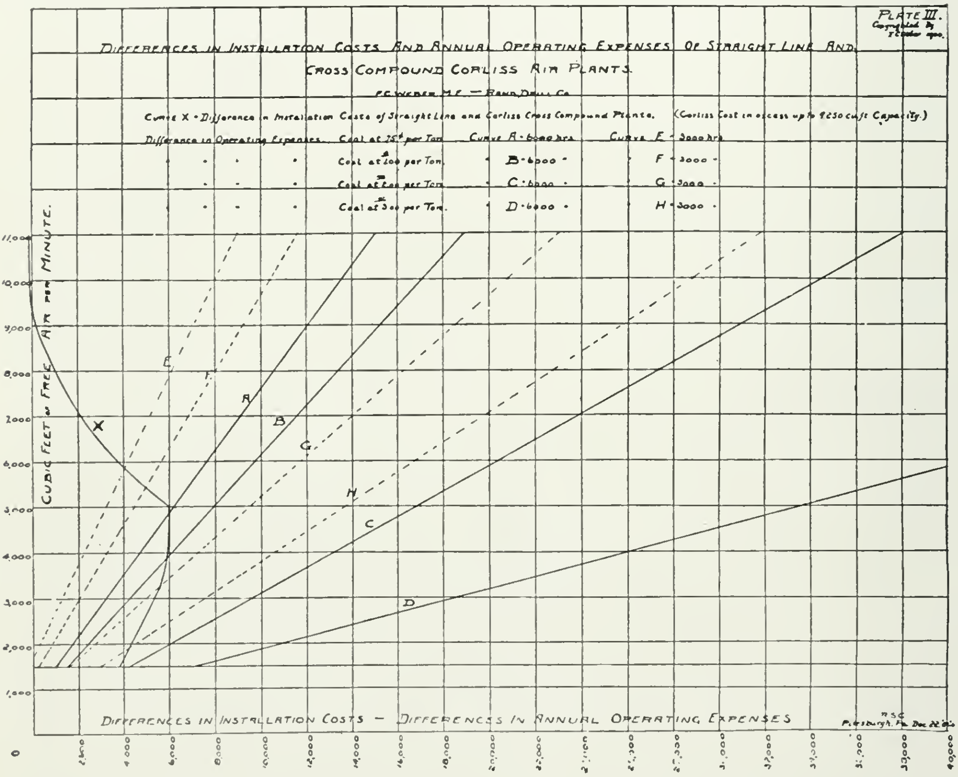


Items.	Straight Line Compressor Plant. (Full Lines)——	Corliss Compressor Plant. (Dotted Lines)...........
Condenser.	Non-Condensing.	Condensing.
Air pressure at receiver, pounds per square inch.	100 pounds	100 pounds.
Steam pressure	100 pounds	125-135 pounds.
Type of steam-engine.........	Single cylinder	Cross-compound cylinders.
Type of steam valve gear.....	Meyer Valve Gear	Corliss Valve Gear.
Type of air compressor......	Single stage	Two stage.
Water rate, steam-engine.....	35 lbs. per I. H. P. per hour..	15 lbs. per I. H. P. per hour.
I. H. P. per 100 cu. ft. free air	20½ I. H. P..................	17¼ I. H. P.
Type of boiler...............	Return tubular	Water tube.
Type of buildings............	Wood structure	Wood and structural steel.
Foundations and piers........	Concrete	Concrete.
Interest on investment.......	4 per cent.	4 per cent.
Depreciation and repairs......	8 per cent.	6 per cent.
No. hours per year considered	6,000 hours	6,000 hours.
Cost of coal at boilers........	75c. to $1.00 per ton	75c. to $1.00 per ton.
Compressor capacity in free air per minute................	1,500 to 11,000 cu. ft.........	1,500 to 11,000 cu. ft.



"fuel costs nothing and need not be considered" is rapidly giving way to the more logical view that any waste is a positive loss and what does the work for one ought to it for some one else, and thereby yield its profits to the producer.

If one mining plant requires from 100 to 150 per cent. more coal than another for a given amount of power, the mine is certainly sacrificing its profit on the *extra* fuel burned, for the coal makes just as good steam under the customer's boilers. Again, if two to two and one half times as much coal is burned for a given amount of power, it costs the mine $1.50 to $2.00, plus selling profit on the fuel burned, for what they could obtain in the more economical type of plant at 75 cents, which is about the average cost per ton to the mine for coal burned under their boilers. Then again, the less economical type of engine requires a larger boiler plant to burn the extra coal to keep up the steam, which means more firemen and more repairs and more trouble with bad water. When this comparison is between the ordinary straight line type of compressor, commonly used by most coal mines, and a cross-compound Corliss condensing two-stage air compressor, the relative difference in economy is quite marked, even for machines of moderate capacities; and to show the relation of these two types of compressor plants to each other as regards *complete* installation costs and operating expenses, the accompanying diagrams were prepared.



As shown in Plates I and II, the free air capacity of the two types of compressors is compared with installation costs and operating expenses for sizes from 1,500 to 11,000 cubic feet per minute. The installation costs are close approximations to actual costs, and would meet general conditions under which such plants are installed in different parts of the country. The difference in first cost and operating expenses between the two types is shown in Plate III.

The operating expenses are based on 6,000 hours' work per year, and the price of coal is taken at 75 cents, $1.00, $2.00 and $3.00 per ton. The last two costs are intended for mines other than coal mines. The conditions assumed in these calculations are such as obtain in general practice and are as shown in table on the following page.

From a study of the results it is apparent that the Corliss compressor has a legitimate field in the coal mine, for even with capacities as low as 2,500 cubic feet, the difference of cost in installation is made up in two years. At 5,000 cubic feet capacity the difference is made up in one year with coal at 75 cents per ton. Beyond this point there is absolutely no question about the economy of the Corliss type of compressor, for the difference in installation costs is a decreasing one, and at 9,500 cubic feet capacity the installation cost of the Corliss plant is less than that of the straight-line compressor plant.

The straight-line plants tabulated here have been favored in many respects, for both types of plants are considered as placed under one roof, whereas the average straight-line plant of four to six machines has at least three to four buildings and separate engineers and firemen.

Aside from its economic advantages, the Corliss compressor possesses mechanical advantages over the other type, that recommend it. It has a higher mechanical efficiency, or less friction, its volumetric efficiency is higher, the lubrication is better, the maximum strains are lower, resistance is more uniform, and its life is longer. The regulation is automatic and is effected through the governor on the cut-off mechanism of the valve gear.

It is generally possible to place the power plant near a stream, so that condensing water can be used; if the stream is not a large one, provision for damming the water can be made at comparatively low cost, so that the condensing water can be used over and over.

As to the advisability of replacing existing line plants with a Corliss plant, the present value of the old plant deducted from that of a new Corliss plant will represent an investment that can yield ample returns through coal saved, such as easily to warrant the change. The boilers need not be changed for better types until worn out.

MODERN METHODS OF ROCK EXCAVATION

Well Drilling Machines Operated by Compressed Air on Heavy Contract Work

In the November issue of COMPRESSED AIR there appeared an article entitled, "A Central Compressed Air Power Plant for Heavy Railroad Construction," by Lucius I. Wightman, E. E. This article described in detail the compressed air installation for work on the low grade freight line of the Pennsylvania Railroad near Safe Harbor, Pa. It is the intention of the present article to describe the work accomplished by the well-drilling machines on this contract more fully than was done in the previous article.

There were forty-two such machines in use and the results attained were so remarkable that we believe they warrant special mention. It will be remembered by those who read the previous article that the plans involved a double track line at a height above the river which would avoid all difficulty from high water; and its object was to remove the congestion of freight traffic on the main line, as well as to reduce the heavy freight hauls which marked this section of the road. Probably, the most difficult conditions were met at a section about nine miles in length beginning on the north, near Columbia, Pa., and reaching to Modic Fords, upon the south. Along this stretch the hills jut into the river with abrupt headlands of solid rock several hundred feet high and, in many cases, almost perpendicular.

The work here consisted of a continuous cut in solid rock and the almost vertical hill-side made necessary the removal of vast quantities of rock with tremendous charges of powder, before the necessary width could be secured at grade. This section is especially interesting and noteworthy in that practically all the rock was removed by heavy blasts, the holes for which were drilled by portable well-drilling machines, operating under compressed air supplied from the central compressed air power plant.

The contractor for this work was H. S. Kerbaugh, Inc., of Philadelphia, who employed forty-two well-drilling machines on this contract, and to whom we are indebted for much of the data contained in this article.

Before describing the operation of these machines in connection with this contract, however, it might be well to state briefly the reasons which led to the selection of these machines for such important work. The above named company had previously undertaken the construction of the Enola Yards for the Pennsylvania Railroad Company. They had three hundred to four hundred laborers drilling holes by hand, using churn drills and drilling to a depth of from twenty to thirty feet. The material drilled was shale and could not be drilled by rock drills. At that time they had ten steam shovels and contemplated adding that many more and working them day and night. The large increase in labor expense and the prospect that even an increase in the laborers would not keep the material loosened up in order that the shovels might dig uninterruptedly, forced them to adopt some better method of drilling. The cutting averaged seventy-five feet deep and it was therefore necessary, with churn drills, to make three lifts, requiring switchbacks and grades of 2 per cent. to get the material from the shovels to the fills. Well-drills were adopted and the cuts were made at grade, doing away with the switch-backs and the 2 per cent. grades. The machines adopted had a drilling capacity of 250 to 400 feet for four and a half to six-inch holes, were fitted with 5 to 6 H. P. reversing engines, and were manufactured by the Star Drilling Machine Company, of Akron, Ohio. With seventeen of these drills, single shifted, it was not only possible to keep twenty-two steam shovels working, but it was possible to keep holes drilled ahead. On the Enola Yard work all the well drills were steam actuated. The holes averaged seventy-five feet deep, five and five-eighths inches in diameter and a drill averaged forty-eight feet of hole drilled per ten-hour shift. In some cases the drills averaged eighty feet per ten hours and in other cases less than twenty feet, this latter being due to caving in of the material and it was sometimes due to the presence of limestone, flint or quartz in the last fifteen feet of the deep drilling.

After such a practical demonstration as this of the advantages to be obtained by the use of well-drilling machines it was natural that H. S. Kerbaugh, Inc., should adopt them in connection with the work at Safe Harbor, although it was an entirely different proposition from the Enola work. The ground to be drilled was hard rock of a gneiss mica schist formation with a small percentage of lime. This rock varied in hardness and the seams were at varying angles to the perpendicular, causing the drills to deflect and adding greatly to the difficulties. In crossing these seams and in straightening up the holes X-bits were used. The first ten to forty feet in some places required casing, but in other places the holes started with the solid rock. The holes were five and five-eighths inches in diameter all the way down and ranged in depth from one hundred to one hundred and thirty feet. The average drilling was nineteen feet six inches per ten-hour shift, but the rate varied greatly, according to the location. On the west end of the work, the rate was sixty feet in ten hours, while at Mann's Run, where the holes were from seventy-five to one hundred and twenty-eight feet deep, the rate was eleven feet per day. At Star Rock one hundred-foot holes averaged fourteen feet per ten hours. At Buzzard Rock, where holes were from one hundred to one hundred and thirty feet deep, the average was nine feet per ten hours. From the Buzzard Rock to Brenner's Hollow, in

BLAST-HOLE DRILLERS OPERATING ON SIDE HILL WORK.

SHOWING THE DIFFICULT NATURE OF THE WORK.

nine thousand feet of solid rock drilling, the holes averaged from sixty feet to one hundred and thirty feet in depth, the rate of drilling being nine feet per ten-hour shift. From Brenner's Hollow to Safe Harbor Viaduct the drilling was from eighty feet to one hundred and thirty feet deep; the average rate being twenty feet per ten hours. The drills on the Safe Harbor work for the first sixty days were steam actuated, and after that time were driven by compressed air, the size of the contract making it advisable to operate as far as

ONE OF THE BLASTS.

possible all machines from a central compressed air power plant, thus affecting considerable saving over the cost of operating numerous temporary boilers scattered throughout the course of the work.

The method of excavation has been that of drilling a number of very deep vertical holes along the inside of the desired cut, and a series of "snake" holes of a suitable depth on a level with the bottom of the vertical holes. These holes were sprung by a charge of dynamite, then loaded with blasting powder and the entire series discharged at once by an electric current from the central power plant. Enormous charges were used and great quantities of rock dislodged. In many instances the major part of the mass was thrown into the river and required no handling, the last rock remaining was loaded in cars by chain shovels and run back over a light railroad to suitable dumping places, but fills were remarkably infrequent.

In carrying out this work the drilling machines were properly located and a branch pipe from the air main connected by a length of hose to the boiler, which thus served as a secondary receiver. No changes were made necessary in the machine itself by the use of compressed air in place of steam for the motive power, the machines working equally well on either. It was found, however, that they did not work effectively with less than eighty pounds pressure. When steam driven they required one driller and two helpers. When air driven, one driller and one helper.

Owing to the difficult positions in which these drills were placed, four men were required for every two drills to carry the bits to the blacksmith shop. In some places horses were used to drag the bits to the shops, while on one section it was necessary to use a horse, and rope and pulley to hoist the bits to a road one hundred and twenty-five feet above the drilling stage to get them to a shop.

All the work in connection with this contract was side hill work. It was, therefore, necessary, in order to place the well-drills on the face of the cliffs, to make roads ten feet wide by hand labor, using in some places rock drills, drilling holes ten to thirty feet in depth. The drilling machines were then propelled along these roads, drilling holes to the required depth. In some cases drills were erected at right angles to these roads in order that a machine could drill holes in projecting points.

The question may arise in the minds of some readers as to how it could be economical to use machines which had to have a special roadway constructed for them along the sides of the cliffs. The answer to this is that the element of economy did not enter into the actual drilling. It was found in the greater efficiency in blasting; more rock being displaced by blasting well-drilled holes, drilled below grade, than by successive lifts of from twenty-five to thirty feet, using rock drills to drill the holes. Rock drill holes were drilled very rapidly but were less efficient when blasted, each bench having to be cleaned off by hand labor except the final one at grade, which was cleaned off by using a steam shovel. The well-drilled holes, once drilled below grade, did the work so well that whatever material was left on the bench could be removed by steam shovels, thus doing away entirely with hand labor.

The horizontal or "snake" holes were drilled by standard rock drills, about two hundred and fifty of these machines, having been used on the work. The holes drilled averaged in depth up to a maximum of thirty-five feet. The deepest holes were four and a half inches in diameter at the top and diminished to one and five-eighths inches at the bottom. As the rock varied considerably in character, the average being of a hardness rather above the ordinary, the service was not easy on the machines and the average of each drill was from forty to sixty feet of hole per day, including the necessary delays due to changing steels and moving positions.

COMPRESSING AIR HYDRAULICALLY

The utilization of water power for the compression of air by entrainment is becoming increasingly frequent. Such a plant has been in operation at Magog, Canada, for some time, a 1,500 h. p. plant has just been put in operation at the junction of the Quinebaug and Shetucket rivers in Connecticut, where it replaces steam in forty engines in neighboring manufacturing plants. A 4,500 h. p. plant is now being completed in Rockland, Mich., to furnish power for the entire operation of the Victoria mine. A highly interesting description of the Quinebaug plant was read in the March meeting of the New England Water Works Association by J. H. Shedd, consulting engineer for the project.

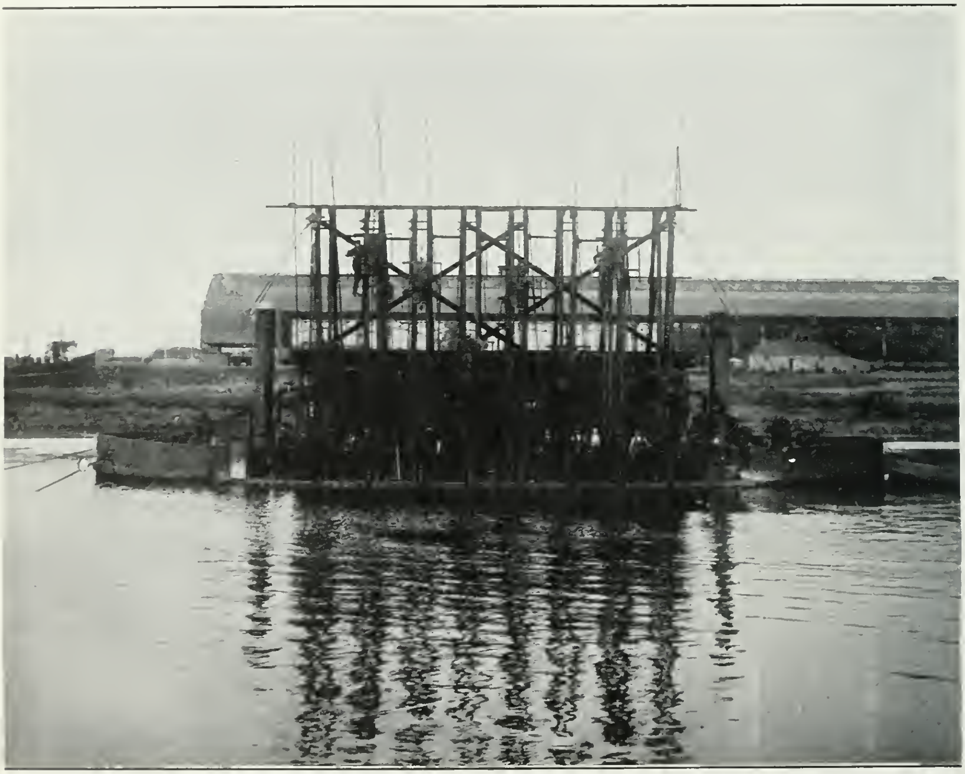
SUBMARINE DRILLING IN THE CLYDE NEAR GLASGOW

By

E. F. Schaefer, M. M. E.

The conditions under which submarine rock excavation must be done are extremely difficult, calling for special apparatus of unusual strength and endurance. This character of work is nearly always carried on where tides, currents, winds and storms are present in varying degrees, and these elements are antagonistic to economical and rapid work, and until recently involved such uncertainty as to require absolute daring to undertake river and harbor excavation; but, add to these troubles, deep water, irregular bottom, covered with mud, sand or other shifting material which fills in almost as fast as removed, and a combination of difficulties results which was, up to the present time, almost insurmountable.

Owing to the increasing submergence of both ocean and lake-going vessels the removal of subaqueos is daily becoming a more important feature. The deepening of channels is possible only because of the improvements which have been made in rock drills, and today such work may be done effectively, rapidly and cheaply. In modern submarine drilling, steels are used anywhere from 30 to 60 feet in length and sometimes they weigh as much as 400 pounds. To drill with such steel in hard homogeneous material is a problem. In poor material and under water, where the drill must be run by the sense of feeling, difficulties are multiplied as it is absolutely essential to have a drill which is at once massive, powerful, durable, and capable of perfect control through all ranges of length of stroke and weight of blow. The drill must, of course, be mounted on a barge, scow or float, fitted with suitable framing to support the drill guides, the drills, the boilers and other auxiliary apparatus. The barge is towed into place and anchored by means of cables, anchor chains or spuds, or a combination of these



SUBMARINE DRILLING IN THE CLYDE.

methods, depending upon the rise and fall of the tides or the currents to be encountered.

In the photograph reproduced in these pages is shown one of the two barges which are, at present, working on the Elderslie Rock Blasting Contract at Renfrew, near Glasgow. The contractors for this work are Messrs. Hill & Co., of Plymouth and London.

The work to be accomplished is of a very extensive nature and consists in drilling, blasting and removing rock for deepening the channel in the Clyde. Many thousands of holes must be drilled, the average depth of each being about eight feet. Occasionally, however, the bed of the river is such that a depth of ten feet is necessary and this drilling must be accomplished through a maximum depth of water of thirty feet.

Each barge is provided with eight Ingersoll Rand Class HA-1 Rock Drills. This drill has a diameter of five inches and a length of stroke of eight inches.

The drills take steam from two boilers on either end of the barge, these being of the Marine Type, working under 120 pounds pressure. They are connected to a main steam pipe which runs behind the drills, and from which branch pipes, fitted with stop valves, are taken. The drills are connected with these branch pipes by means of steam hose. Immediately below the stop valves are hand winches which are used to feed the drills to the work or to raise them from it. The drills are supported in guides and suspended by wire ropes which pass over pulleys at the top of the frame and under pulleys at the bottom, thus allowing a very accurate feeding of the machines. Behind these winches is a secondary and smaller winch provided with a wire rope to hoist the drill steels from the holes and replace them preparatory to drilling. The winches and the handles of the stop valves are in close proximity so that one man can handle each machine.

Submarine tubes which are used in this contract consist in each case, of long lengths of four-inch screwed piping which may be extended to meet the rise of the tide. These tubes are forced through the over-lying mud, sand or gravel, to the rock-bed and serve to keep the advancing hole free from extraneous matter. The holes are drilled exactly as in the case of drilling down holes on land, the drill being fed down as far as possible, then being run back, a longer steel inserted, and so on, until the desired depth is reached, when the steel is removed and the hole charged with explosive through the tube. The casing tube is then removed, the wires connected with the blasting battery and explosion effected without shifting the barge.

A further feature of the plant is the cages situated at either side of the drills, permitting any adjustment to be made while the machines are in operation. From the time of starting the first drill to finishing the set of eight holes, the average time consumed is from two, to two and a half hours. This work is so extensive in character that up to the present time nearly two years have been devoted to it, and before its completion there is a possibility of operations being continued for another year. The drills have satisfactorily met all the difficult conditions encountered in this subaqueous excavation and are being employed with perfect success in the operations on the Clyde. In practically every submarine undertaking of any importance, embracing the pioneer work in New York Harbor, dozens of United States Governmental undertakings, in the Iron Gates of the Danube and Prussia, Portsmouth, England, Panama Canal, Havana Harbor, Cuba, Boston, and many great works in the Great Lakes and other undertakings, both Governmental and private, in all parts of the world, these rock drills have been used, and thus is added to the already long list another undertaking of considerable importance.

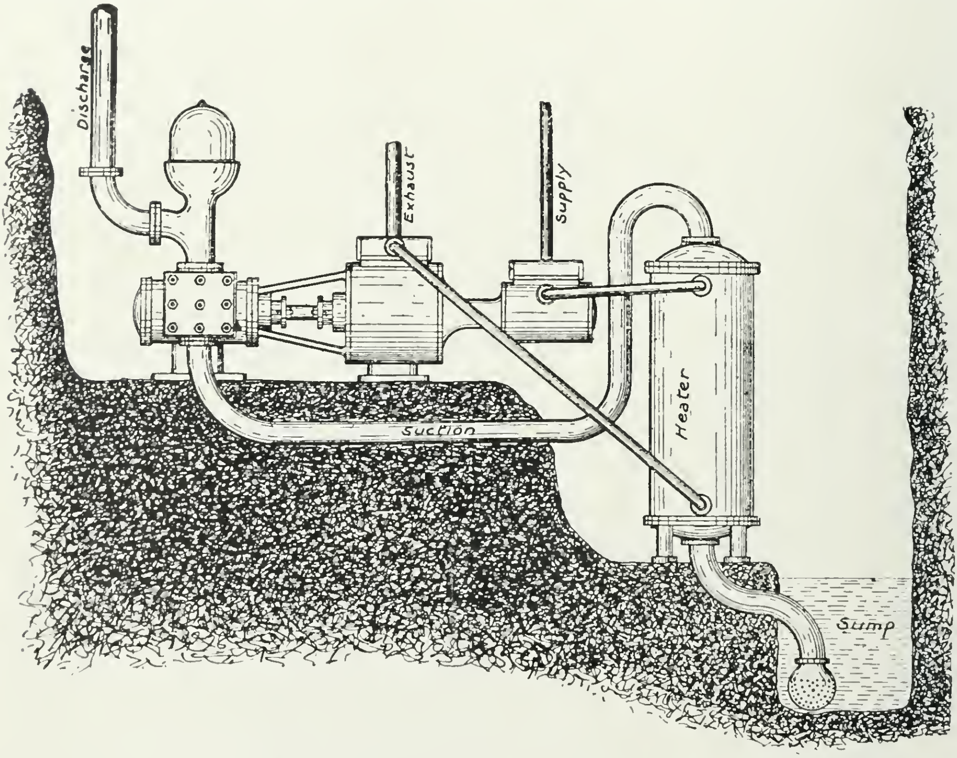
COMPRESSED AIR IN THE LONG ISLAND CITY POWER STATION

The Pennsylvania, New York & Long Island Railroad Co. have just completed a large power house at Long Island City, in which compressed air has been installed very extensively for cleaning and other purposes. Air is supplied by two Westinghouse motor driven compressors, operating on a 220 volt electric current Each compressor has a capacity of 50 cu. ft. of free air per minute delivered at 100 lb. pressure, and is controlled automatically by a pump governor. The compressed air is used for cleaning the main and auxiliary generators, switchboard apparatus and electrical accessories, and also in connection with the oiling system for forcing new cylinder oil and new crank case oil into the storage tanks from which these oils are delivered to the oiling system. It is also used for an air hoist for handling oil barrels and emptying them into the receiving tanks. The pressure usually carried on this system is 80 lb. gage.

COMPRESSED AIR PUMP WITH WATER-HEATED REHEATER.*

BY L. C. BAYLES.

A simple and economical improvement was made at the Gwen mine, Calaveras county, California. It was necessary to lift 200 gal. of water per minute to a height of 600 ft. At first this water was raised with a direct-acting sinking pump. The compressed air was furnished by a separate compressor which only supplied this pump and a hoist. It was found that when the pump was shut down the compressor was obliged to make 20 r.p.m. to operate the hoist and overcome pipe leakage.



FEED WATER HEATER USED AS AIR RE-HEATER.

With the pump in operation the speed of the compressor was 55 r.p.m., establishing the fact that the pump consumed the air compressed by 35 r.p.m. of the compressor. It was not considered advisable to install a re-heater of any of the standard types, but the engineer devised a simple method of obtaining practically as good results without the costs involved in firing a re-heater.

The sinking pump was discarded and a direct-acting compound pump was installed in its place, along with a Wainwright feed-water heater. This feed-water heater was placed in the suction pipe of the pump, so that all the water passed through it before reaching the pump. The supply of compressed air was first led into the high-pressure cylinder, where it did a certain amount of work, and then passed into the shell of the heater at about 35 lb. pressure. Having been allowed to perform a certain amount of expansive work in the high-pressure cylinder, the temperature of the air entering the feed-water heater was reduced to a low point—in fact, the temperature of this air was below freezing point. As the air passed through the feed-water heater, its temperature was brought up to that of the water, which was about 70 deg. The air then entered the low-pressure cylinder, where it again performed some expansive work before escaping into the atmosphere. The slight fall in the temperature of the water being pumped was of no account. It was found that when this pump was put at work, the compressor was able to supply both the hoist and the pump when making only 35 r.p.m. In other words, the single-cylinder pump used 130 per cent. more air than the compound pump and the feed-water heater.

The amount of compressed air required

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*From the Engineering and Mining Journal.

could have been still further reduced if a pump of the fly-wheel type had been especially designed for this case, with water-jacketed cylinders and discharge pipes, in which case the expansion could have been carried much further without danger of freezing. It goes without saying that the installation of a heater, which would have brought the temperature of the air up to 350 deg. before it entered either cylinder, would have reduced the amount of air the compressor had to supply for this pump to one-third of the quantity required for the single-cylinder pump using cold air. The cost of installing a pump and heater, such as just described, would not exceed the cost of a single-cylinder pump by more than about 50 per cent., which difference would be more than saved in the first two months.

I believe that, while not showing anything like as high efficiency in test runs as where reheaters are used, which bring the temperature up to between 300 and 400 deg., this method of using compressed air will be found the most satisfactory for general underground pumping, especially in cases where small pumps are required, and that it is efficient enough to make compressed air the most desirable motive power for the majority of underground pumps.

CLEANING THE HIPPRODROME BY VACUUM PROCESS

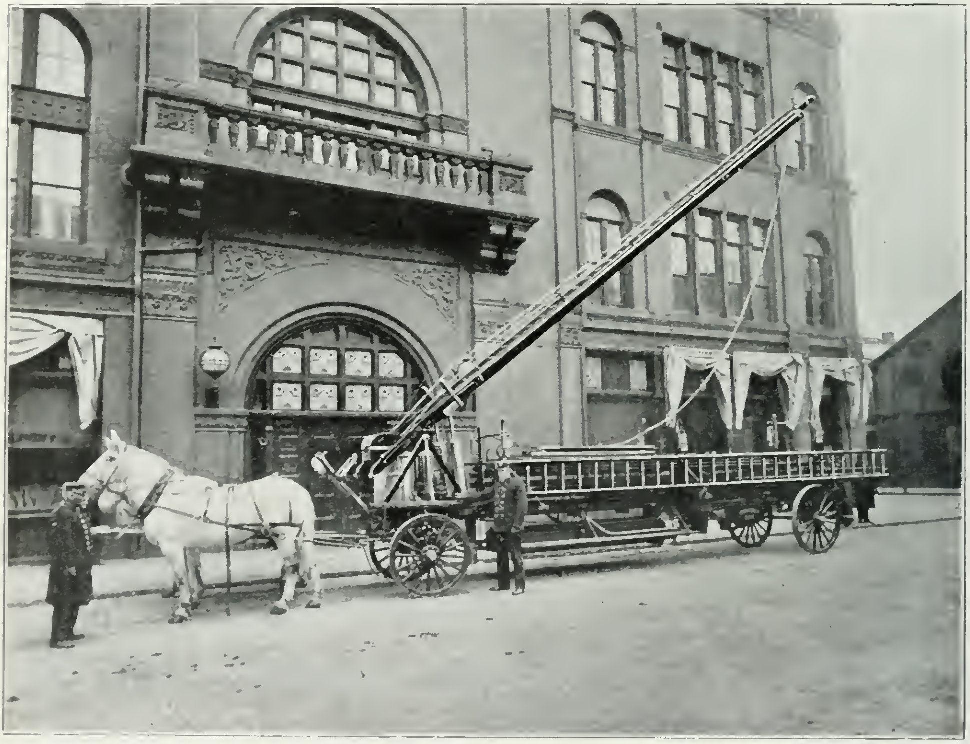
The accompanying illustration shows the wagons of the Vacuum Cleaner Company upon the stage of the New York Hippidrome. This great playhouse is cleaned at regular intervals by the vacuum system, which is probably the most sanitary method of extracting dust from carpets, cushions, floors, walls, etc., without disseminating it in the air. The Hippodrome, however, is not the only theatre which has adopted this method of cleaning, as many of the leading theatres in New York City and elsewhere throughout the country have either installed a permanent plant of the vacuum type or else use the portable wagon system at regular intervals. The vacuum system is controlled by the Vacuum Cleaner Co., of New York, who have established branch offices in many of the large cities of the country.

HOOK AND LADDER OPERATED BY COMPRESSED AIR.

There has recently been tested in New Bedford, Mass., a compressed air device for raising ladders on hook and ladder trucks.

The illustration shows the general appearance of this device, which consists of two brass cylinders mounted vertically upon the turntable of the hook and ladder truck. Pistons, operating in these cylinders, are connected by rods to the side bars of the ladder. Air is stored in a tank under 300 lbs. pressure, and is passed through an intermediate compartment filled with non-freezing fluid before being led to the operating cylinders. An automatic cut-off valve shuts off the supply of air as soon as the ladder reaches a perpendicular position. The whole operation is under the control of one person who manipulates the throttle valve, by-pass and exhaust valves.

This device may be applied to almost any hook and ladder truck, but is especially adapted to the type known as the "Hayes" truck. It is said to be simple, safe and easy of operation, one man being able to raise the ladder from its bed to an upright position as fast as is consistent with safety; in fact, the ladder has been raised in five seconds, but it is not considered advisable to raise a ladder, 75 feet or over in height, in less than seven seconds. One charge of compressed air is sufficient to raise and lower the ladder at least ten times. The device is manufactured by the Pneumatic Aerial Appliance Co., of New Bedford, Mass.

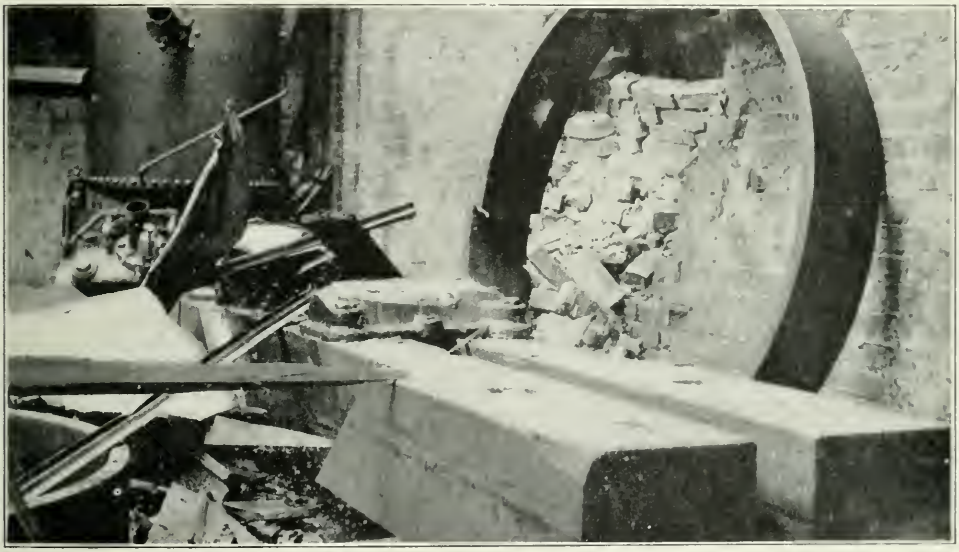


AN ALIBI FOR AN AIR COMPRESSOR.

BY FRANK RICHARDS.

Two or three months ago, at a structural iron works at 136th street and Madison avenue, New York, there was an explosion in the night, followed by a fire which destroyed the entire building. As an explosion has occasionally occurred in connection with an air compressor, when driven hard without proper cooling arrangements, it was suggested that the compressor was the cause of the trouble in this case. A little investigation showed the absurdity of the charge and established a complete alibi for the compressor. The compressor was not there at the time. That is, it was not there as a compressor, for it was not in operation. Besides that the part of the compressor which could by any possibility have exploded, the air cylinder, was entirely intact and uninjured.

The snap-shot half-tone tells the whole story. The compressor, which was a small one with an electric motor and a belt drive, was located near a wall, and between the wall and the compressor a charge of dynamite had been exploded, shattering practically every part of the compressor except the cylinder, which projected at the back of the machine and was out of the field of action. In the picture the air cylinder is in the left hand background, close under the air receiver, and the rim of one of the wheels leans against the wall. The base of the frame is shown still bolted to the timbers.



Dr. Walter T. Scheele, consulting chemist of Baltimore, has been granted a patent upon his process of preserving with liquid air. This is said to be the first patent ever granted in this country or abroad for the commercial appliance of liquid air.

A corporation will be formed to develop the patent and eight others now before the United States Commissioner. Mr. William J. Hooper, of Baltimore, is the promoter. Baltimore and New York capitalists are interested.

AN INDUSTRIAL COMPRESSED AIR RAILWAY.*

COMPRESSED AIR LOCOMOTIVES IN THE ANACONDA COPPER MINING COMPANY'S NEW REDUCTION WORKS AT ANACONDA, MONTANA, U. S. A.

In May, 1905, the writer became indebted to Mr. E. P. Matthewson, manager of the Anaconda Copper Mining Company's new reduction works, for opportunities offered to study their rather novel compressed air system of transportation. Compressed air locomotives are used at these works more extensively and continuously than at any other mine or works in the world. The Anaconda reduction works are operated twenty-four hours per day, and seven days in the week.

The company works eleven or twelve compressed air locomotives for sixteen hours each day, and nine for the remaining eight hours. It owns thirteen locomotives, as under the conditions practically continuous work is essential, and a spare locomotive is required in order that necessary repairs may be made. Twelve of these locomotives weigh 26,000 pounds each, have cylinders 9½ inches in diameter by 14-inch stroke; driving wheels 28 inches in diameter; a rigid wheelbase of 54 inches; main storage tanks of 132 cubic feet capacity; tractive force 5,700 pounds. The remaining locomotive weighs 42,000 pounds, has cylinders 12 inches in diameter by 18 inches stroke; driving wheels 36 inches in diameter; a rigid wheelbase of 60 inches; main storage tanks of 218 cubic feet capacity; tractive force 9,180 pounds.

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*By C. B. Hodges, in Cassier's Magazine.

The main storage tanks are charged, at intervals of from twenty minutes to one hour, with air at a pressure of from 700 to 800 pounds per square inch, which is then reduced to a pressure of about 150 pounds for use in the cylinders of the locomotives. When the pressure in the main storage tanks, as shown by a gauge facing the engineer, has dropped to a point near 150 pounds per square inch, the locomotive is stopped at the next charging station and recharged, this operation of recharging taking from one to two minutes.

The machinery on these locomotives is in most respects the same as would be employed on a steam locomotive of the same size, the chief difference being that the cylinders are ribbed, in order that they may the more rapidly absorb heat from the atmosphere, instead of being lagged to prevent the loss of heat, as in the case with steam locomotives. The compressed air goes into the main storage tanks on the locomotives at atmospheric temperature, and falls to a temperature far below that of the atmosphere during the expansion in the cylinders. This feature has an important bearing upon the relative efficiencies of the three great powers—steam, electricity and compressed air, under certain conditions.

An electric motor is an inefficient machine while coming up to normal speed; a steam engine is inefficient until the walls of the cylinders are thoroughly heated; but a compressed air engine is most efficient, thermodynamically, with the first movement of the piston, because the walls of the cylinders are then at their highest temperature. This fact would point to the use of compressed air locomotives wherever stops and starts are to occur with great frequency. The main storage tanks on the air locomotives replace the boiler, and need but little description. They are exceptionally good pieces of work, having required no repairs during four years of service; they are to-day practically bottle-tight. The locomotives stand for hours without perceptible loss of pressure.

The regulating valves on the locomotives deserve special attention. To make the locomotives successful, this piece of apparatus must at all times maintain, with the minimum amount of attention, a practically uniform pressure in the small auxiliary reservoir located between the regulating valve and the throttle valve, and be absolutely tight when the locomotive is at rest. How well the regulating valves on these locomotives perform is evident to anyone who rides on them. The gauge-hand that indicates the pressure in the auxiliary reservoir is apparently glued to the 150-pound mark on the gauge while the locomotive is in motion, and it seldom rises above 175 pounds while the locomotive is at rest.

The compressed air required by the locomotives is furnished by two compressors, having cross-compound steam cylinders equipped with Corliss valve-gear, and four-stage air cylinders. The compressors are duplicates. The high-pressure steam cylinder is 20 inches, and the low-pressure steam cylinder, 40 inches in diameter; all air cylinders are single-acting; the intake air cylinder is 37¼ inches in diameter, first intermediate cylinder 20¼ inches, second intermediate cylinder 12½ inches, high-pressure cylinder 6 inches, and the common stroke is 48 inches. The intake and first intermediate cylinders are placed behind one steam cylinder; the second intermediate and high-pressure cylinders behind the other. All the air cylinders are water-jacketed, and intercoolers are provided for cooling the air after each stage of compression.

The compressors are equipped with automatic speed and pressure governors, and an examination of the sheets taken from the recording gauge shows that the regulation of pressure is absolutely perfect. They are operated with steam at 150 pounds pressure and with a vacuum of 17 inches in the condenser, perfect vacuum at the elevation being 24 inches. The rated speed is 70 revolutions per minute; the horse-power developed per revolution, 8.7; the steam consumption per horse-power-hour when operating at a speed of 55 revolutions per minute, 18.67 pounds. The company intends to improve the vacuum in the near future, which will undoubtedly result in a lower steam consumption.

The remainder of the haulage equipment consists of a system of piping varying in size from 2 to 6 inches. This serves two purposes: First, it connects the compressors with the various charging stations; second, it provides a reservoir containing a reserve supply of compressed air at a pressure in excess of that required by the locomotives, and sufficient to charge one or two locomotives instantaneously. Although this pipe line sustains a pressure of 950 pounds per square inch and consists of several thousand feet of pipe of various sizes, with many branches, valves, and charging station connections, leaks are extremely rare and it requires a rather tedious search to discover one. The losses due to this cause must be small indeed, as a leak of any importance is readily heard by any person within a radius of 10 feet.

The compressed air locomotives are operated over about 18 miles of standard gauge track laid with 60-pound rails, located inside of an irregular area about half a mile square. The reduction works are located on a side hill, and the locomotives, in doing their varied work, pass from the bottom of one building to the top of another, under the dripping bins from which the concentrates are drawn, and over, under and around the furnaces, in an atmosphere of heat, dust and sulphurous acid, with sharp curves, steep grades, and loads that tax their capacity to the extreme limit.

PERFORMANCE OF COMPRESSED AIR LOCOMOTIVES

Number of Locomotives	MATERIAL	Quantity in Net tons	Weight in Lbs. of Empty Car	Average W'ght in Lbs. of Load on each Car	Number of Cars per Train	Number of Trains per Shift	Number of Shifts Worked	Distance in Feet
1	Coarse concentrates, first-class ore, converter lining and lime rock	1200.	7,500	16,666	12	6	2	7,000
1	Fine concentrates	1746.54	6,400	18,192	6	10 or 11	3	2,000
1	Coal	360.	6,200	6,545	6 or 7	5 or 6	3	3,400
2	Calcines............	1450.	6,500	10,175	3	32	3	1,500
1	Hot metal.............................	731.42	23,200	19,505	1 or 2 seldom 3	13 to 15	3	1,800
3	Coarse concentrates, flue-dust, first-class ore, clay and lime rock	3600.	4,200	4,286	2 trains 16 cars 1 train 20 cars	53	3	1,600
1	Miscellaneous	1400.	32,000	53,000	1 or 2	13	3	1,000
1	Miscellaneous	950.	6,400	9,000	1 to 20	12	2	1,000
	Total	11,437.96						

	MATERIAL	Grade	From	To	See Note	Ton-Miles Exclusive of Locomotives Net	Gross
1	Course concentrates, first-class ore, converter lining and lime rock	2% F. L. *	Upper part concentrator	Stock bins	A	2,120	4,027
1	Fine concentrates....................	1% A. L. +	Lower part concentrator	Roaster building	..	662	1,127
1	Coal..................................	Level	Stock bins	Reverberatory furnaces	..	282	671
2	Calcines	Level	Roaster	Reverberatory furnaces	..	412	938
1	Hot metal.	Level	Reverberatory and blast furnaces	Converter	B	207	684
3	Coarse concentrates, flue dust, first-class ore, clay and lime rock	Level and 2½% A. L +	Stock bins and brick plant	Blast furnaces	C	1,090	3,225
1	Miscellaneous		Between all points		D	267	581
1	Miscellaneous		Between all points		D	110	340
	Total..					5,170	11,593

NOTE A.—A 42,000-pound locomotive. This locomotive also shifts 5 or 6 standard railroad cars per day, and also one large wood car per day, equivalent to about 2 more round trips per shift.

NOTE B.—Each round trip includes trip through Y for cleaning ladle and three weighings.

NOTE C.—Each round trip includes side trips to various locations under stock bins and to brick plant, then to blast furnaces.

NOTE D.—Miscellaneous shifting of standard railroad cars and plant cars, handled by both locomotives. This work is roughly estimated.

*In favor of loads. +Against loads.

Outside the buildings the locomotives are subjected to extremes of weather. At an elevation of 5,000 feet above sea level, at Anaconda, Mont., the range of temperature is from 95 degrees above zero to 35 degrees below, with heavy snows and high winds. Under these conditions the records of the company show that the compressed air locomotives, during the months of January, February and March, 1905, lost 5¾ hours for one locomotive out of a total of 23,320 locomotive-hours, distributed among thirteen locomotives. These records show all delays chargeable to failures of the transportation system and are kept with great exactness.

The new reduction works were first operated in February, 1902. The locomotives in question have been the only means of internal transportation since the first pound of copper was produced, and the nine original locomotives, purchased in November, 1900, which were used during construction, are still in service and apparently as good as new, except for the necessity for regular running repairs. The tabulated data on page 4077 give a rough idea of the work which is being performed.

It should be understood in reviewing the table that it does not by any means represent all the work done by the locomotives. The first omission is the movement of the locomotives themselves, both when hauling trains and when running light from point to point; second, the endless "spotting" and shifting that is necessary in order to weigh, load and unload the material hauled. For example, in the case of the locomotive hauling hot metal, the cars or ladles must be "spotted" for weighing three times on each round trip, in addition to three other stops—two for loading and unloading, and the third for cleaning the ladle, this latter operation being performed on a spur leading off a Y.

In the case of the three locomotives hauling coarse concentrates, first-class ore, flue dust, slag, and limestone from the stock bins and brick plant to the blast furnaces, each carload must contain its proper proportion of each of the various ingredients, and each car must be "spotted" under the proper chute and weighed after each class of material is put in. At the other end, the train of from sixteen to twenty cars is moved back and forth eight or ten times in placing the various cars so that they can be unloaded in the proper place, in the proper furnace. Even the easiest runs involve at least two weighings of the train—one loaded and the other empty—and several shifts to place the cars at the proper points for loading and unloading. All this is necessary in order that the efficiency of the various operations may be traced at all times.

Samples of crude ore, concentrates, calcines, slags, flue dust and the metallic product of the blast and reverberatory furnaces, together with the black copper from the converter, are taken daily and analyzed. This combination of systematic weighing of all materials after every process, with daily sampling and analyses, enables the management to detect and stop promptly any unusual losses in the process.

To do this work, locomotives were required that were self-contained, reliable, powerful, smokeless, compact and simple in operation. With steam locomotives the smoke and steam in the tunnels under the bins and furnaces would have made it almost impossible for the locomotive runner to see the signals. Electric locomotives would have required trolley wires or a third rail, either of which would have introduced serious difficulties in many locations too obvious to require explanation. Storage battery electric locomotives might have been used, but they are not adapted to severe and continuous service, and require too long a time for recharging the batteries or changing the cells.

When the reduction works were built the engineers in charge decided in favor of compressed air locomotives as the best solution of the transportation problem. Their successors who now operate the plant apparently agree with them, as they have purchased additional compressed air locomotives, and have extended the system to cover movements of materials which the constructing engineers did not consider in connection with the original design. The writer heard but little criticism and much commendation. The general opinion of the operating force is thus summarized: Under their conditions, compressed air locomotives are unsurpassed for convenience, reliability, and simplicity of operation.

Taking up the question of economy, the labor cost of operating the system is as low or lower than it would be with any other system. With them the cost of power is also extremely low, as the steam is generated by waste heat from the reverberatory furnaces; but as the question of steam economy is of considerable interest under other conditions, and as an absolute determination was impossible under the circumstances, the writer will attempt a few comparisons, trusting that they may be found of interest.

During the month of April the two compressors were operated continuously twenty-four hours a day, one at an average speed of 38.8 revolutions per minute; the other at 44.1

revolutions per minute. Under these conditions the total power developed would be 721 horse-power for both compressors, or an average of about 66 horse-power for each locomotive in operation. Ten out of the eleven locomotives in operation will develop 5.700 pounds tractive force; the remaining locomotive will develop 9.180 pounds. The speed is limited to 5 miles per hour.

Each one of the smaller locomotives would therefore be developing

$$\frac{5700 \times 5280 \times 5}{60 \times 33000} = 76$$

horse-power at times; the large one

$$\frac{9180 \times 5280 \times 5}{60 \times 33000} = 122$$

horse-power, giving a total of $76 \times 10 = 760$, added to $122 = 882$ horse-power.

The approximate kilowatt input of an electric locomotive of the same weight as the smaller type of compressed air locomotive would be 95, and for the larger size 150; total, $95 \times 10 = 950$; $150 \times 1 = 150$; $950 \times 150 = 1100$ kilowatts.

If we assume that not more than one-half of the total rated capacity of the locomotives, to which must be added 5 per cent., we have 550 kilowatts, or $550 \times 1.34 = 737$ electrical horse-power at the locomotives, to which must be added 5 per cent. for line losses, 5 per cent. for dynamo losses, and about 7 per cent. for the friction of the engine; $737 \times 1.17 = 862$ for the indicated horse-power of the engine driving the dynamo to operate the same number and weight of electric locomotives, with occasional overloads and the extreme fluctuations incident to the operation of electric locomotives. It does not seem, therefore, as though electric locomotives under the same conditions would be much more economical of steam.

As compared with steam locomotives, in order to make an intelligent comparison we must go back to the coal pile, even though the steam necessary to operate the compressed air locomotives at the reduction works is obtained from boilers that are run by waste heat.

The two compressors, under normal conditions, required 323,100 pounds of steam per day of twenty-four hours. By referring to the table on page 4077 we see that there are thirty-one eight-hour locomotive shifts in each day of twenty-four hours. Assuming, for the sake of comparison, an evaporation of 7½ pounds of water per pound of coal, we find that to furnish steam for the compressors, 43,080 pounds of fair coal would be required, or, say, 1,400 pounds of coal per compressed air locomotive shift. The writer has in his possession reports on the performance of twelve steam locomotives, having cylinders 9 inches in diameter by 14 inches stroke, which used from 700 to 2,400 pounds of coal per day of ten hours, averaging about 1,340 pounds.

Assuming that steam locomotives at the reduction works would use approximately the same quantity of fuel per hour, we have 1,072 pounds for the small locomotives per shift, and 1,500 pounds for the large one, giving a total of $1,072 \times 29 = 31,088$, $1,500 \times 2 = 3,000$, $31,088 + 3,000 = 34,088$, or, say, 17 tons of coal for the steam locomotives doing the same work, as against 21½ tons for the compressed air locomotives.

These calculations are, of course, nothing more than crude approximations, and are presented only as indicating that any change which might be effected in the cost of steam to operate the transportation system by substituting another form of motive power would be of minor importance when considered in connection with other expenses and the other desirable qualities of the existing system.

The cost of maintenance must certainly be less than with steam locomotives by about the amount necessary to wash out and keep in repair thirteen small locomotive boilers, as the cost of keeping the main storage tanks on the compressed air locomotives in repair has been nothing. The remainder of the machinery of the compressed air locomotives being so nearly the same as that of the steam locomotive, there is no reason why there should be any difference in the cost of maintenance. The writer is of the opinion that the repairing of saddle tanks and the renewing of grate bars on steam locomotives would about balance any expenditure for maintenance of a stationary plant, including the boilers

In comparing the cost of maintenance with electric locomotives no such direct deductions are possible. The machinery is radically different, and the friends of both systems claim superiority in this respect for their favorites. With the electric locomotives, dust and dirt are more easily kept away from the wearing parts; but the same casing that keeps out the dust prevents the free circulation of air around the armature and commutator, and renders them more liable to injury from overheating. So little reliable data is to be had that it is all a matter of opinion. Figures have been published showing that compressed air locomotives are more economical to maintain than are electric locomotives, but there are no detailed and reliable figures to show electric locomotives more economical than compressed air locomotives.

One set of figures, however, does not settle the matter. Probably local conditions and designs have more to do with the relative cost of maintenance than any inherent qualities of the two systems. Compressed air locomotives have this advantage: Charge after charge of air may be used in quick succession, with the locomotive working at all times at full capacity without injury. This is not true of electric locomotives. The electric motors which drive the locomotives are so designed that they can be run for one hour at rated draw-bar pull and speed without injurious heating, provided the motors are started cold. As a rule, this provision is sufficient, but occasionally it is not, and a burnout occurs.

The problem of internal transportation in many large establishments is a serious one, and during the writer's stay at Anaconda the many advantages of compressed air locomotives for such service were so manifest, and the evidence that their development had reached a stage justifying the confidence of engineers and business men was so conclusive, that a brief account of what was being accomplished with this form of motive power seemed of general interest.

Compressed air locomotives, however, have their limitations. They are not intended for long continuous runs in one direction, and their efficiency would be relatively low where starts and stops were infrequent; but for service conditions similar to those existing at the Anaconda Copper Mining Company's new reduction works there would seem to be a wide field of usefulness, more especially where waste heat from heating or blast furnaces, or the refuse from woodworking establishments, or water power, could be utilized to operate the compressor, thus saving the fuel necessary to operate steam locomotives, doing away with trolley wires, and eliminating all risk of fire.

AIR COMPRESSOR LUBRICATION

Mines and Minerals makes the following statement in regard to the lubrication of air compressors:

"Excess of lubrication, in addition to waste, means increased accumulation of combustible matter, increased lodgment of dust and increased danger of accident. Just as little lubricant should be used as possible.

"Two lubricants are in general use on air compressor cylinders, a mixture of soap and water, and cylinder oil. Either can be made to do the work. The mixture of soap and water has inferior lubricating properties and must be used in quantities. One case of explosion is reported where soap and water was used almost exclusively. A test of the deposit found in the receiver after the explosion showed that it readily ignited at 400 degrees F., the deposit being 2 inches thick.

"The mixture of the soap and water was also tested in a laboratory and upon being evaporated down to a 'black semi-solid mass' ignited at 500 degrees F. The principal combustible ingredient in the deposit was coal dust.

"This case is sufficient to show that the use of soap and water is not a sure preventive of accidents. In fact, it goes further and shows that soap and water may not be as good as oil, for the tests showed that it burned readily when dry, and in-as-much as more of it would have to be used than of oil, the deposit of dust would be correspondingly greater. Nevertheless, soap and water may be used to good advantage and provision should be made for its introduction into the cylinder when necessary."

* * *

FRANCIS FOX states that the length of the Simplon tunnel, which is 12½ miles, is greater than was planned by 31 inches. The levels of the two galleries were within 3½ inches of one another. The axis of the tunnel, driven from the north end, deviated 4⅓ inches toward the west, while the line driven from the south end deviated 3⅔ inches toward the east; the greatest divergence from the true line, 3⅓ inches, is well within probable error.—*Engineering and Mining Journal.*

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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PUBLISHED BY
THE KOBBÉ COMPANY,
90 92 West Broadway,
New York.

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. JUNE, 1906. No. 4.

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AIR LIFT PROBLEMS.

We should like to call the attention of our readers to the inquiry of Mr. William Schock in regard to his air-lift system, which we print under the head of "Practical Items for Practical Men," in this issue of COMPRESSED AIR. While we have given Mr Schock what information we could in regard to his problem, we should like to hear from our readers and obtain their opinions in this matter. As far as we can determine nothing has been written upon the subject of carrying water horizontally in air lift pumping plants and there is, therefore, no information regarding the effect of horizontal piping upon the capacity or efficiency of the system. It is out of the question to look to the manufacturers of air lift pumping systems for this information as it is against their policy to give out any more data than they can help, owing to the fact that the gathering of such data has been of great expense to them and they do not wish to allow their competitors to profit by it. This stand may be a perfectly correct one and justified by competition, but at the same time the information is of considerable value and offers an excellent opportunity for original research on the part of engineers who are in a position to make the necessary tests. It also offers an original subject of investigation to technical graduates who desire to break away from the time-worn theses subjects usually adhered to. If, therefore, any of our subscribers have any information on this subject, they will be conferring a lasting benefit on a large number of the readers of this magazine if they will make their knowledge public.

DENATURALIZED ALCOHOL.

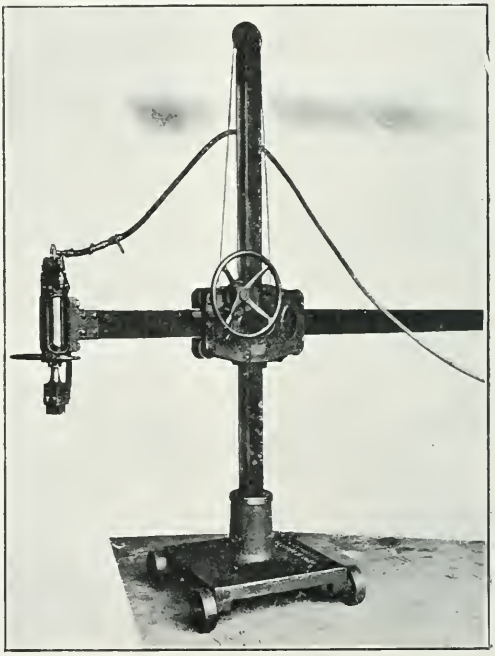
There seems to be a better chance this year than ever before that Congress will pass the bill removing the internal revenue tax on denaturalized alcohol for use in the arts. The House, at this writing, has already passed the measure and the Senate will show an unmeasurable indifference to public opinion if it fails to do its share in making this important bill a law.

Denaturalized alcohol free of tax will compete most successfully with kerosene as an illuminant and with gasolene as fuel. In Germany and Great Britain denaturalized alcohol has been untaxed for many years, and has been used in enormous quantities for various manufacturing processes. For illuminating it is used with a Welsbach mantle and will give 1,471 candle-power hours per gallon burned, as compared with 783 candle-power hours from a gallon of kerosene burned in a kerosene lamp. Tests at the University of Brussels have shown that alcohol at 31 cents per gallon is as cheap for lighting purposes as kerosene at 15 cents per gallon.

For use in motors, alcohol does not possess quite so great an advantage. Its efficiency is substantially the same for this purpose as gasolene, about one pint per horse-power hour. While alcohol only possesses half the number of heat units per pound that gasolene does, the alcohol vapor can be compressed to a much higher degree than gasolene without causing premature ignition, and, consequently, the thermal efficiency of the alcohol engine can be made about 30 per cent., as compared with 21 per cent. to 22 per cent. for the gasolene engine. The exhaust from an alcohol engine contains a less number of injurious gases than the exhaust from gasolene motors, and it has been proposed, therefore, to build alcohol locomotives for use in mines. Even with the higher efficiency, however, it is to be doubted whether alcohol will compete successfully with gasolene unless its cost can be materially reduced, it being estimated that it cannot be manufactured for less than 25 cents per gallon. In Cuba, however, it is said to be produced on sugar plantations from refuse molasses at a cost as low as 10 cents per gallon. It is to be hoped, therefore, that improved processes may be developed so that denaturalized alcohol may be produced for 15 cents per gallon, or less, in this country, in which case it would prove a most valuable fuel for the operation of direct combustion engines, the supply being practically inexhaustible and, it being possible to manufacture alcohol almost anywhere, there will be no necessity for payment for long freight hauls.

A NEW STONE DRESSING MACHINE

The Thomas H. Dallett Co., of Philadelphia, has lately brought out a new large stone dressing machine of the sliding-arm type. The tool has several novel features. By taking off two nuts at the top of the tool, the valve-box, valve, piston and barrel can be removed, and on being replaced, there are no adjustments to be made, the parts being replaced in their order and the nuts screwed down tight. Economy in the use of air has received a great deal of attention during the design and development of the tool, not only to render it long-lived, but also to reduce the air consumption to the minimum. At 80 lb. pressure the tool will consume about 50 cu. ft. of free air per minute, and at lower pressure a correspondingly less quantity. All parts of the tool are hardened and accurately ground. The exhaust hose can be attached to either side of the tool, blowing the dust from the working surface of the stone in either direction, as the operator may desire.



The upright consists of two parallel bars, with separating pieces between, the whole securely riveted together. On the lower end of this standard is cast a massive cylindrical journal, becoming an integral part of it and forming as a whole a bifurcated rotatable upright. The journal rotates in the bearing formed in the upright extension of the base. This bearing is lubricated with grease and protected from the cutting action of the stone-grit by a leather cap, which fits over the top of the bearing. The bearing surface is 17 in. long and 6½ in. in diameter.

The horizontal arm carrying the tool is a 6-in. I-beam, with the sides faced with oak. This arm travels back and forth on rollers mounted in the carriage, which is movable up and down on the upright by means of the hand-wheel, drum and ratchet, as shown in the cut. The position of this horizontal arm between the bars formin the upright, throws all the weight and strains directly through the centre-line of the upright, which is important in minimizing wear and is conducive to easy operation.

The rollers of the carriage, on which the horizontal arm travels back and forth are a very hard cast iron, with case-hardened bushings inserted. The side plates and the different parts of the tool holder are crucible steel castings. Another important feature is the spring device in the carriage, whereby a constant tension is maintained between it and the upright. This eliminates wear and rattling of the carriage on the upright, besides allowing a flexibility of movement, to a certain extent, of the tool over the inequalities of an uneven stone that is of much assistance to the operator.

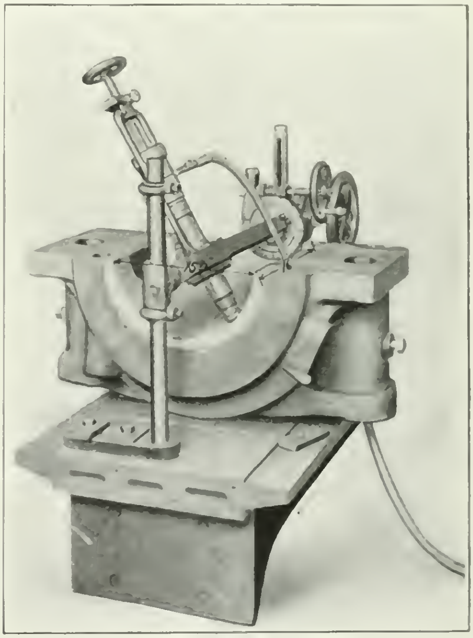
The base of this machine weighs 700 lb., which is sufficient to insure the stability of the machine when the carriage is at the top of the upright and the arm fully extended, without the necessity of weighting down or clamping to the track. The base is ordinarily furnished with flat wheels, as shown in the cut, but when desired flanged wheels will be provided. The net weight of the machine, complete, is 1,600 lb.

For the export trade the Dallett Co. has adopted a novel expedient to save freight charges incident to forwarding to foreign countries the heavy iron base. For export they provide what they term their "export base," which is simply the upright bearing, provided with a flange on the bottom, so that it may be bolted to any description of base that the foreign purchaser may desire. The weight of this bearing is about 200 lb., so that when boxed for shipment the whole machine, with the export base, complete, weighs 1,400 lb., and occupies but 26 cu. ft.

PNEUMATIC BABBITT BEATING MACHINE.*

The pneumatic babbitt beater, shown in the accompanying illustration, was designed and patented by Charles Hightower, late assistant superintendent of the Union Iron Works, of San Francisco, Cal. It will undoubtedly fill a long-felt want in the machine shop—not only from a practical standpoint, but from an economical one as well.

Beating babbitt by hand, as we all know, is very expensive and at the same time not altogether satisfactory. The job is usually done by one of the shop laborers, who does not understand the importance of properly beating the babbitt, until it is well into the dovetails provided for securing it in place, and at the same time closes up the pores of the metal, together with any possible blowholes that might have occurred in pouring, and to this fact may be traced a good deal of the trouble given by babbitted journals and surfaces. While the work done by the machine may also have its faults if the machine is not skillfully handled it will be seen that there is no comparison between the two methods of beating babbitt as far as the cost of production goes. The cap, shown in the illustration, is 16 inches long, with a bore of $15\frac{1}{2}$ inches, and it was beaten in nine minutes. The machine, as may be seen, is of very crude construction, having been built entirely for experimental purposes. As the principle is clearly shown in the cut, consisting of a suitable frame for holding and traversing a pneumatic hammer an explanation as to the construction and operation is hardly necessary; sufficient to say that it gives entire satisfaction and promises to be a welcome addition to the modern machine shop.



Intelligent rock drillers will usually drill long holes when possible. Comparatively short holes must be used in stoping in some places, but the policy of putting in long holes, even if they are of smaller diameter at the bottom, is not contrary to the best practice.

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*By W. S. Atkinson, in Machinery.

The Editor of "Compressed Air":

Dear Sir—Will you kindly favor me with the information as to the proper distinction between compressed air and air delivered by a blower or fan? Thomas G. Saxton.

Compressed air is generally considered to mean air above 20 or 30 lbs. gauge pressure. A centrifugal fan or blower is not adapted to maintain a pressure higher than about 16 oz., and any pressure between this and 20 lbs. is maintained by a blowing engine. A blowing engine is practically the same as a compressor except that its exhaust valves are usually positively controlled. Compressed air for commercial purposes is usually used at pressures from 60 to 100 lbs. gauge.

The Editor of "Compressed Air":

Dear Sir—Would you please let me know the capacity in free air per minute of a compressor 3⅛ inch bore, 4 inch stroke, speed 500 R. P. M. single acting? Also how close the piston must come to the cylinder head to compress 100 lbs. William Scott.

A compressor of the dimensions stated above, operating at 500 R. P. M., single acting, would displace 8.75 cu. ft. of free air per minute. This would be piston displacement only, however, and would not represent the capacity of the machine unless an allowance were made for volumetric efficiency. As the volumetric efficiency of high speed machines is usually low, the machine in question would probably not deliver more than 7 cu. ft. of free air per minute. In regard to clearance in this compressor, there is no set rule, as it is universal practice to make the clearance as small as is mechanically practicable. Some companies have a rule that clearance in all sizes of machines shall not be greater than 1-16 inch between piston and cylinder head. It will be seen, therefore, that if the distance between the cylinder head and piston remains the same for all sizes of cylinders, the percentage of cylinder volume, represented by this clearance, increases as the diameter of the cylinder decreases.

OXY-ACETYLENE BLOWPIPE.

The oxy-acetylene blowpipe produces a very high temperature, being in the neighborhood of 4,000 degrees C. It promises to be a very valuable means of welding plates together and for other purposes requiring high temperature. The proportion of oxygen and acetylene may be regulated so as to make the flame either an oxidizing or reducing agent simply by giving excess of oxygen or acetylene as may be desired. One great advantage of the new blowpipe is that both oxygen and acetylene gases may be generated as desired, thus doing away with the necessity of transporting them in cylinders under high pressure. The acetylene gas is of course generated by the combination of water and carbide of calcium, and oxygen may now be produced by the combination of water and peroxide of sodium which is sold under the trade name of "oxone."

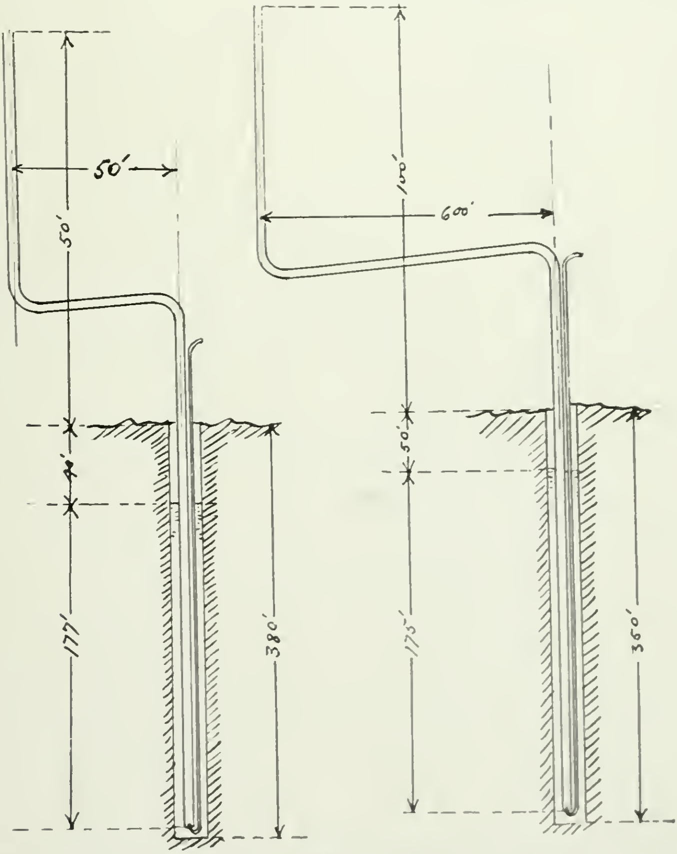
EDISON AIR REHEATER.

The Edison air reheater consists of two concentric cylinders. In the inner one a coal fire is built, while a portion of the compressed air is passed through the space between the cylinders, and a portion is conducted through the fire. Valves are arranged to regulate the proportion of air passing through the fire. The work is intermittent, as the reheater must be opened and emptied before a fresh supply of fuel can be added. When properly lagged with asbestos, 90 per cent. of the heat units of combustion are imparted to the air as well as all the gases produced by the burning coal. The result is that a horse-power may be added to the compresser air by burning 0.4 lb. of coal. This is far below results obtained in any type of steam or gas engine. Two men are required to operate it, and the temperature to which it will raise is uncertain. Sometimes the fire goes out after the reheater is closed; sometimes too much air passes through the fire, and all the ashes are carried along with the air; and sometimes the fire burns so hot that the air is raised to temperatures which make lubrication impossible, even exceeding 1,000 degrees Fahrenheit.

PRACTICAL ITEMS for PRACTICAL MEN.

WHAT'S THE MATTER WITH THIS AIR LIFT SYSTEM?

The above inquiry was made to us by Mr. William Schock, who states that the system was supposed to raise 150 gallons of water per minute from both wells combined, but that the most he can get from them is from 90 to 100 gallons per minute.



ROUGH SKETCH OF WILLIAM SCHOCK'S AIR LIFT SYSTEM.

The wells are operated by a compressor having a 10" x 14" cylinder and operating at 100 r. p. m. Air pressure at receiver equals 90 lbs. gage. Discharge pipe equals 3" diam. Air pipe equals 1¼" diam. for both wells.

This compressor should have a displacement capacity of 127 cubic feet of free air per minute.

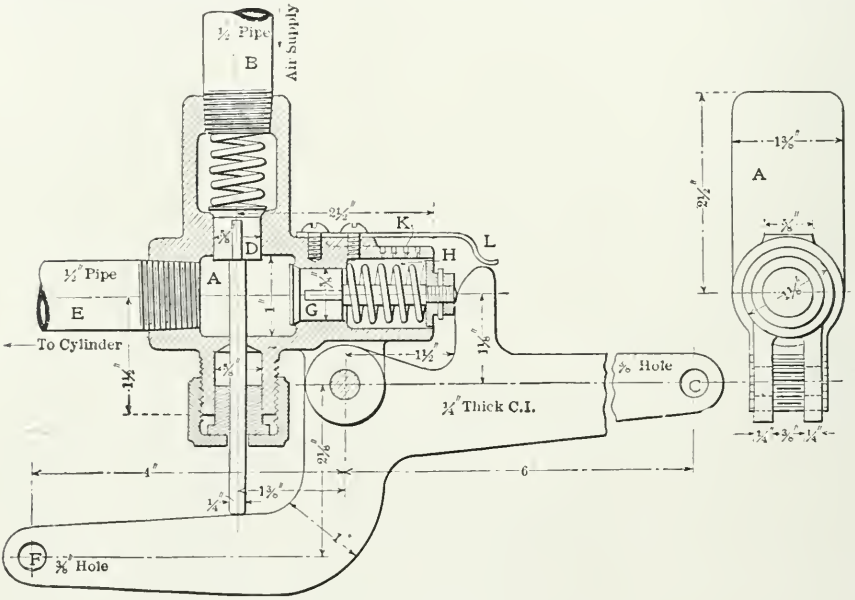
The other conditions relating to this problem can be obtained from the drawings.

We should be interested in hearing from our readers in regard to this subject.

To convert a machine-drill into a trip-hammer, simply upset a piece of drill-steel, forming a proper head thereon, and place this in the chuck in the same manner that you would the drill, tightening the bolts. The machine, of course, should be properly secured by means of strong "U" bolts to a suitable timber frame, so constructed that the anvil may be placed in position underneath the drill. When all is ready turn on the air, the same as though you were going to drill a hole in the rock. The intensity and speed of the blows is regulated by the amount of air turned in, or by the pressure, which may be controlled. No special valve gear or any change in the machine is necessary.

OPERATING VALVE FOR AN AIR HOIST.

The writer had occasion to build several air hoists recently for use in various departments of our works. These hoists were of the single-cylinder straight-lift type, the cylinders being made of 4½ and 6-inch thin tubing of various lengths, four feet being the usual lift required.



OPERATING VALVE FOR AN AIR HOIST.

The principal parts of these hoists were the operating valves, which are illustrated in the accompanying sketch. They have proven very satisfactory.

The body *A* is a brass casting with the air inlet through the ½-inch pipe *B*. To cause the hoist to lift, the hand rope which is attached to the operating lever at the hole *C* is pulled downward, thus lifting the valve *D* from its seat; the air then passes through the valve *D* into the chamber *A* through the ½-inch cylinder pipe *E*, which leads to the under side of the hoist piston. When the load is raised to the required height and it is desired to lower it, the hand rope at *C* is released and the valve *D* will fly down upon its seat, where it is held by the coiled steel spring and the pressure in the supply pipe; the load will remain at this height until released, provided there are no leaks. To release the load, pull the rope attached at the hole *F* in the lever, thus pushing the exhaust valve *G* from its seat. The air in the hoist then passes out through the pipe *E*, the chamber *A*, the valve *G* and the chamber *H* to the atmosphere through the small perforations *K* which muffle the exhaust. The exhaust valve is held on its seat by a coiled steel spring; this spring also assists the 1-16x½-inch flat steel spring *L* in keeping the operating lever in a horizontal position.—*American Machinist.*

A GOOD scheme for washing blue-prints is that seen at the general office of a mining company not long since. The tank in which the prints are washed is vertical, instead of horizontal (as usual), and has at the top a shade roller about 3 in. diameter. This rests upon a pair of rollers at each end, and turns freely; a perforated pipe is arranged at one side of it, and delivers small streams of water against the face of the blue-print. The latter, preparatory to washing, is pinned together at the ends and the shade-roller inserted; the roller, with the print hanging from it into the tank, is replaced and the water turned on. A quick turn of the roller, together with the streams of water directed against the print, keeps the latter in motion for a sufficient length of time to insure thorough washing.

CHIPPINGS.

The Stanley-G. I. Electric Mfg. Company have opened temporary offices at 67 Blake Block, Oakland, Cal. Several carloads of electrical apparatus have already left Pittsfield to take the place of machinery damaged or destroyed in the California disaster.

It is not claimed even by air compressor builders that compressed air is a cheap medium for developing power underground; but in almost every mine there is to be found one or more places where a compressed-air pump is the simplest, most convenient and most desirable way of handling the water at that point.

We are advised that the Sullivan Machinery Co. have established a temporary office at 1010 Washington street, Oakland, Cal., to take the place of their regular San Francisco branch recently destroyed. They are now in a position to give prompt attention to orders through Mr. H. T. Walsh, Pacific Coast Manager, who is carrying a stock of rock drills and parts as well as air compressors.

Ores and Metals announces that from this time on it will be published by Reinert Brothers, of Denver, Col. Under the new management the paper has been enlarged and considerably improved both in appearance and in the quality of its contents. Those who know the present publishers have no doubt that the improvement will continue. The new *Ores and Metals* will be edited by Mr. Carl H. Paddock.

To heat 700 cu. ft. of free air from 60 deg. to 355 deg. F., when under 65 lb., requires 12,800 B.t.u. per minute. Allowing 50 per cent. as the efficiency of the reheater (a figure which tests of standard types have shown to be fair), we must develop 25,600 B.t.u. in the reheater per minute, which will require about 2 lb. of coal per minute, or about 2900 lb. per 24 hours. These calculations are based on installation at an altitude of 5,000 feet.

Quite an interesting drilling competition was recently held on the Lancaster West mine. On this mine kaffir labor is employed, while Chinese are used on the next mine, the Lancaster. The white miners of the Lancaster West boasted they had a Kaffir who could drill better than any Chinaman. A competition was arranged and the Chinaman beat the Kaffir easily, drilling 156 in. in about 7 hours, while the Kaffir drilled 140 in. It is found that the Chinaman is an excellent driller provided the conditions are favorable. Otherwise he loses heart.—*Engineering and Mining Journal.*

As to "star" vs. "chisel" bits, some drillmen say that in all cases star starters and seconds should be used. Then practical knowledge on the part of the man and his boss must decide as to whether the conditions are most favorable to the use of chisel or star. According to one opinion, an ideal set of drills is made of 1⅛-in. steel; starters, 3 in. diameter; seconds, 2½ in.; thirds, 2 in.; a long star, 1¾ in., and then chisel up to 9 ft. or 10 ft. Drills of the same length in the same set should vary in the size of their cutting edges.

It is almost useless to attempt to reach a conclusion as to the relative merits of air and electric drills. There are so many considerations that no definite statement can be made save in individual cases, where the natural prevailing conditions are a deciding factor. The air drill is considered to be less easily broken than the electric drill, but on the other hand it is claimed that air installations suffer greater line losses and are less efficient. The electric drill is growing in favor, but still has an enormous lead to overcome.—*Mining Reporter.*

Compressed air locomotives, which in the past few years have become so largely used for mine haulage, work under pressures ranging from about 500 to 2,000 lb. The pressure is mainly determined by the size of the locomotive permitted by the tunnels and curves. In tunnels of good size the large reservoirs needed for low pressure engines are permissable, but where only small receivers can be used, it is necessary, in order to carry the required supply of power, to compress the air to a higher degree in strong steel tubes, "bottles" as they are sometimes called—*Engineering and Mining Journal.*

The present standard type of air reheater consists of two concentric cylinders having about ¾-in. space between them. A coal fire is maintained within the inner cylinder, which is provided with a gate at the bottom end, and a smoke pipe at the top. The compressed air is conducted through the space between the cylinders where it takes up about 50 per cent. of the heat units developed by the combustion of the coal, the remaining 50 per cent. escaping up the stack and by radiation. In tests made with reheaters of this type, in which the air was raised from 52 deg. F. to 350 deg., an increase of 54 per cent. was found in the work performed by a given amount of compressed air.

A plant for the manufacture of liquid air, purchased out of the Boylston hall laboratory funds, has recently been installed in Boylston hall, Harvard. It consists of a four-stage compressor, built by the Norwalk Iron Works Company, which is operated by a Crocker-Wheeler 20-horse-power motor. The compressed air is condensed by a new and original type of liquefier designed by Prof. W. P. Bradley of Wesleyan university and built under his direction. The capacity of the plant, which is the most efficient and powerful yet devised, is about half a gallon of liquid air per hour.

In the compressed-air street car service tried in New York some years ago the compressed air was stored in a tank under high pressure, while a second tank containing hot water was used as a reheater, the air being allowed to pass through the water before entering the engine. In trials made with these cars it was found that when using the reheater a car would run over six miles on one charging of the air tank, while without a reheater it would only run between three and four miles.—*Engineering and Mining Journal.*

A new hoisting rope should be oiled within two or three days of its being put to work. The oiling should be repeated at least once a month during the first six months, and after that every six weeks. In a dry downcast shaft this may be considered needlessly frequent, but in an upcast, or a wet shaft, it may be required more often. The process of oiling affords an excellent opportunity for examination of the condition of the rope. The oil can be removed by cotton waste, soaked in paraffin, from any part where a defect is suspected.

Pneumatic locomotives are employed in some of the large German collieries. The engine is constructed like an ordinary steam locomotive. An air-storage tank takes the place of the boiler. The air is stored under pressure varying from 700 to 1,000 lb. per sq. in. In some of the engines the air passes into an auxiliary reservoir before entering the cylinders. The air pressure is reduced to about 150 lb. per sq. in. before entering the engine cylinder. The air is used expansively by means of the Stephenson link-motion gear. This system of underground haulage is cheaper and handier than rope haulage, and it is thoroughly safe and reliable.

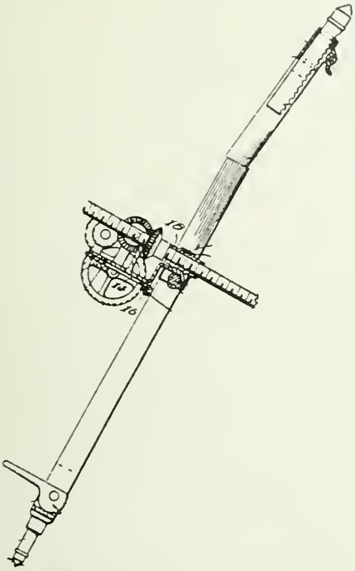
A practically necessary feature in mining in the Cripple Creek district in Colorado is the use of the rock drills driven by compressed air. The air compressor plant is usually placed near the mouth of the shaft and the air supplied to the drills at different levels through pipe lines extending down into the mines. The mines are worked at various levels, reaching a working depth in several instances of 1,000 feet. The rock encountered, especially at the lower levels, is very dense and not easily drilled. The economical operation of a mine in this district thus depends largely on the cost of compressing air, owing to the high price of coal. The range in the cost of coal for this work is from 53 cents to $3 per drill shift. This difference is, of course, due to the care and intelligence with which the machinery is operated and to the design and character of the latter.

The results obtained in two mines of the Cripple Creek Consolidated Co. covered by a period extending over four months are interesting in demonstrating that low costs can be obtained in practice under proper operating conditions. During the four months referred to 1,367 drill shifts were operated in these mines, 492 shifts being the largest number employed in a single month. The cost of coal used in operating the two mines during this time was $1,183.17, of which $450 was spent for coal used in hoisting 7,500 tons or rock that was removed. The total cost of coal required in operating the compressor was thus $733.17, or 53.7 cents per shift. A straight-line air compressor, with single steam and compound air cylinders, made by the Sullivan Machinery Co., of Chicago, Ill., was used. This compressor is designed to operate 10 standard rock drills, but the rated capacity was often exceeded during the time mentioned.

U. S. PATENTS GRANTED APRIL, 1906.

Specially prepared for Compressed Air.

816,562. Miner's Drill. Clyde C. Cranmer, Athens, Ohio. Filed March 2, 1905. Serial No. 248,174.



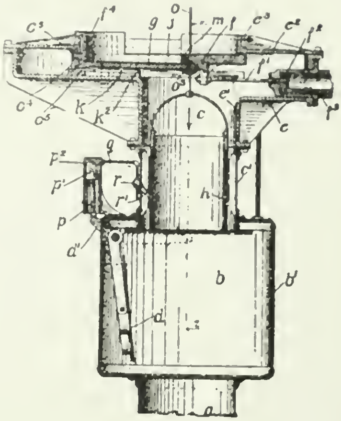
Claim.—1. In a miner's drill, the combination of a supporting-post, a supporting-frame connected with the upright, and a slidable plate carried by said supporting-frame and adapted to hold the same in an ascertained position.

816,563. Miner's Drill. Clyde C. Cranmer, Athens, Ohio. Filed Sept. 12, 1905. Serial No. 278,161.

Claim.—1. In a miner's drill, the combination of a supporting-frame, a drill-rod mounted thereon, a rotatable bearing for the drill-rod having threaded connection therewith, a main gear having spline connection with the drill-rod and adapted to rotate the same, means for actuating said main gear, adjustable bearing-brackets attached to the frame, and a train of gears mounted on said bearing-brackets and arranged to connect the main gear aforesaid with the rotatable bearing, whereby rotation may be imparted to said bearing, adjustment of the bearing-brackets above mentioned being adapted to connect or disconnect the main gear from the rotatable bearing as described.

816,642. Air Lock. Sinclair W. Chiles, South Bethlehem, Pa. Filed June 15, 1905. Serial No. 265,416.

Claim.—1. In an air-lock, the combination of a movable head having an aperture for the passage of the bucket and adapted, when moved in one direction to partially close the air-lock chamber, a valve member operatively connected with the head to close the aperture therein when said head is moved to partially close the air-lock chamber.



816,761. Pneumatic Horse Collar. Ingebert J. Thomsen, Minden, Neb. Filed Aug. 22, 1905. Serial No. 275,267.

Claim.—1. The combination with a horse collar of pneumatic pads connected by a restricted air passage, and a valve controlling the passage of air through said air passage.

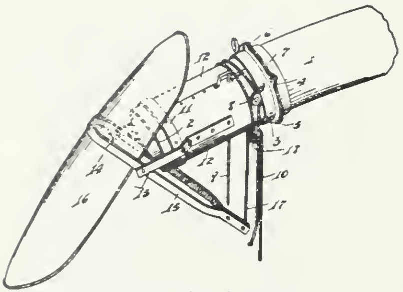
816,859. Fluid Pressure Brake. Maury W. Hibbard, Chicago, Ill. Filed July 6, 1903. Serial No. 164,324.

Claim.—1. In an automatic fluid-pressure brake apparatus, having a movable abutment, governing the passage of pressure to the brake cylinder, and a passage for feeding pressure from the train pipe to the auxiliary reservoir, the combination of a separate movable flexible diaphragm device exposed on opposite sides to pressure from the train pipe and auxiliary reservoir respectively, and a valve in said feed passage actuated by movement of said diaphragm device to open said passage when the train-pipe pressure exceeds that in the auxiliary reservoir.

816,884. Detachable Pneumatic Tire. Chas. S. Scott, Cadiz, Ohio, assignor, by mesne assignments, to The Goodyear Tire and Rubber Company. Filed March 23, 1905. Renewed March 5, 1906. Serial No. 304,264.

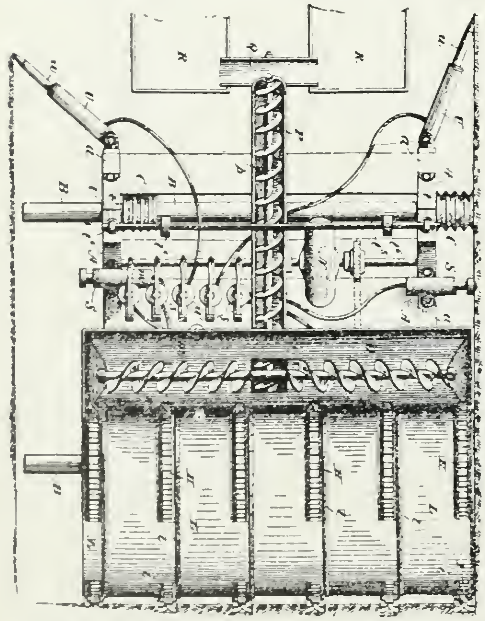
Claim.—1. The combination of a vehicle-wheel rim having a depressed groove near its detaching edge, an annular, inextensible, detachable, rim flange, having an inner diameter which permits its ready passage over the outer edge of the groove, and a contractible locking ring which is passed over the outer edge of the groove and sprung into the groove to form an abutment for the rim flange, substantially as described.

816,897. Distributing Nozzle for Pneumatic Conveyer Pipes. Oscar E. Bray, Warsaw, N. Y. Filed Dec. 27, 1904. Serial No. 238,310.



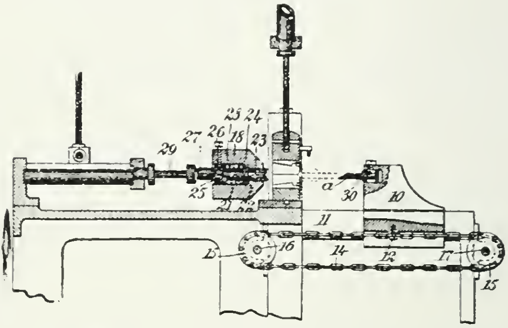
Claim.—1. A distributing attachment for pneumatic conveyor-pipes, having in combination a sleeve rotatably engaging over the end of said pipe, a plurality of collars rigidly fixed to said pipe, one at each end of said sleeve, strut members projecting from said sleeve past the outer end of said pipe, a directing-shield, a holder carrying the same, pivotally mounted between said strut members, and a plurality of cord system, one whereby the sleeve may be rotated in either direction with respect to the pipe, and the other whereby the position of said deflecting-shield and holder with respect to the sleeve and the pipe-terminal may be regulated, substantially as described.

816,923. MACHINE FOR CUTTING HEADINGS. William A. Lathrop, Wilkes-Barre, Pa. Filed Aug. 31, 1903. Serial No. 171,437.



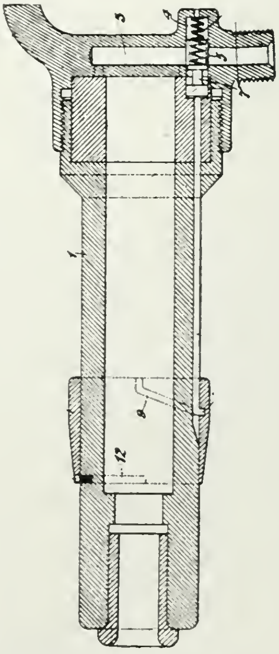
Claim.—1. In a machine for cutting headings, the combination of a cutter adapted to cut a channel transverse to the machine, which channel shall be as long as the corresponding transverse dimension of the machine, and means for moving said cutter laterally to widen said channel.

816,961. DRILL SHARPENING MACHINE. James J. Brossoit, Grand Rapids, Wis. Filed Dec. 20, 1904. Serial No. 237,599.



Claim.—1. In a machine for sharpening drills, the combination of a housing having a passage therethrough and a shoulder in the passage, a die arranged to move in the passage and having a shoulder coacting with the shoulder thereof, a collar secured in the housing, through which collar the die moves, a spring bearing between the shoulder on the die and said collar, and means for operating the die.

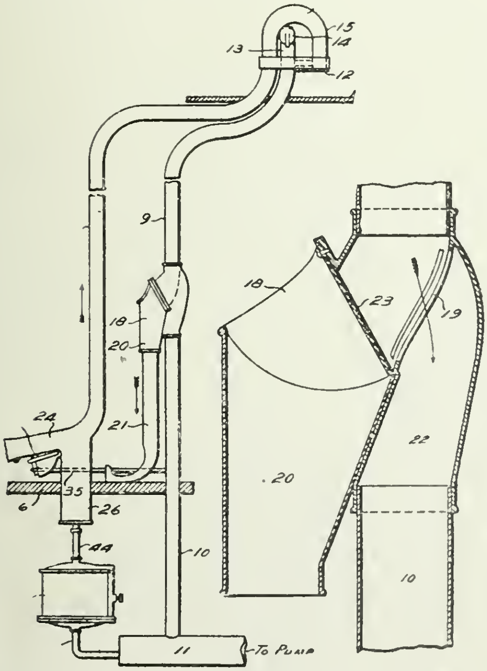
816,998. THROTTLE-VALVE FOR PNEUMATIC HAMMERS. Henry S. Potter, Bromley, England. Filed Jan. 4, 1905. Serial No. 239,661.



Claim.—1. The combination, with a power-cylinder having a closed rear end, of an oscillatory hand-operated sleeve encircling the front end portion of the said cylinder, means for preventing the said sleeve from moving longitudinally, a supply-valve arranged at the rear end of the said cylinder, and a rod connection between the said sleeve and supply-valve.

2. The combination, with a power-cylinder having a closed rear end, of an oscillatory hand-operated sleeve encircling the front end portion of the said cylinder and provided for controlling the supply of pressure fluid, a toothed pinion gearing into the said rack, and a rod connection between the said plug-valve and pinion.

817,016. PNEUMATIC DESPATCHING TUBE SYSTEM. Joseph J. Staetzel, Chicago, Ill., assignor to Universal Pneumatic Transmission Company of Maine. Filed Nov. 20, 1905. Serial No. 288,175.



Claim.—1. In a pneumatic-despatch-tube system, the combination of a normally closed transit-tube through which carriers are transmitted, a sending-station arranged to permit a carried to be inserted into the tube, means for exhausting air from the tube, and a valve adapted to admit air into the tube for driving carriers, said valve being adapted to open through a fluctuation of the pressure within said tube, means normally urging the closing of said valve, and means for timing the closing of said valve.

817,066. PNEUMATIC TIRE. Sidney Hunter, St. Louis, Mo. Filed Sept. 21, 1905. Serial No. 279,435.

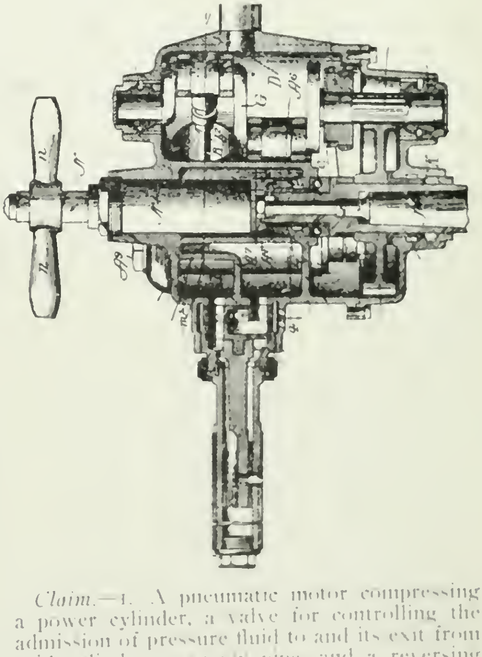
817,296. TUBULAR ROCK-BORING DRILL. William Besson, Duluth, Minn. Filed March 31, 1905. Serial No. 253,037.

Claim.—1. In a drill, the combination of a tubular drill rod, a reservoir formed on and around said rod at its lower end, a tubular drill point secured to the lower end of said rod, and having passages formed therein connecting the central passage of said drill point with said reservoir.

817,306. VACUUM SOLDERING MACHINE. Holton Eachus, Chicago, Ill., assignor to Fairbank Canning Company, Chicago, Ill., a corporation of Illinois. Filed May 6, 1905. Serial No. 259,207.

Claim.—1. The combination with a movable carrier having a plurality of compartments, and a plate adapted to cover two or more of said compartments successively as said carrier moves and having a suitable opening therein, of a vacuum chamber covering said opening, grooves in said plate connecting with said vacuum chamber and adapted to expose said compartments successively to the action of the vacuum as said carrier moves them under said plate, and means for soldering the vent in the caps of the cans contained in said compartments as they pass under said vacuum chamber, substantially as described.

817,384. PNEUMATIC MOTOR. Reinhold A. Norling, Aurora, Ill., assignor to Aurora Automatic Machinery Company, Aurora, Ill., a corporation of Illinois. Filed July 20, 1904. Serial No. 217,372.



Claim.—1. A pneumatic motor compressing a power cylinder, a valve for controlling the admission of pressure fluid to and its exit from said cylinder, a supply pipe, and a reversing valve embracing a valve casing with which said supply pipe is connected, said valve casing being provided with an outwardly facing valve seat having two ports, both of which are in communication with said cylinder by supply and exhaust passages controlled by said cylinder valve, a rotative valve-disk bearing on said seat and adapted for bringing either of said ports in communication either with the air-supply pipe or with the outer air, a valve-operating stem connected with the valve and extending into said supply pipe, and a sleeve mounted to turn on said pipe and forming a hand grip, said sleeve being connected with said valve stem by operating means extending through a slot in said pipe.

817,538. COMPOUND AIR PUMP. Howard Wixon, Chicago, Ill. Filed July 1, 1904. Serial No. 214,920.

Claim.—1. A compound pump comprising an outer, low-pressure cylinder having an internal packing at its end, a high-pressure cylinder working through said packing and having an external piston working in said outer cylinder, a piston carried by said outer cylinder and working within said inner, high-pressure cylinder, said cylinders being in unobstructed communication at a point between said pistons, substantially as described.

817,609. CHUCK FOR ROCK DRILLS. Thomas E. Adams, Cleveland, Ohio, assignor to The Adams Drill Company, Cleveland, Ohio, a corporation of Ohio. Filed June 29, 1903. Serial No. 163,601.

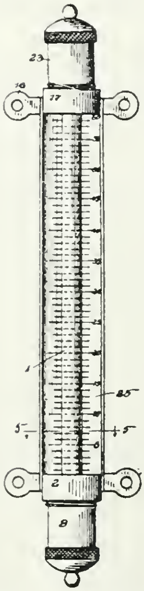
Claim.—1. A drill-chuck having a tapering exterior made with a continuous series of step-like ribs.

817,706. AIR AND GAS ENGINE. Allen O. Heney, Shakespeare, Ind. Filed Dec. 21, 1904. Serial No. 237,778.

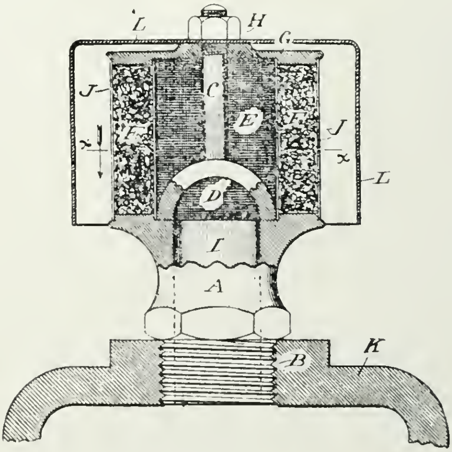
Claim.—An air and gas engine, employing a cylinder having an inner piston-chamber opening into the intake end of said cylinder, and oppositely-moving pistons, said piston-chamber having a single inlet-port also communicating with said cylinder-intake end and delivering the gas and air charge, after initial compression, to the opposing action of the pistons, said inlet-port also adapted to be shut off by one of said pistons in its forward or compression movement, and said piston-cylinder also having a single exhaust-port adapted to be uncovered by the opposite piston, in its rearward movement, after the exploding of said charge, substantially as set forth.

817,778. AIR PRESSURE AND VACUITY INDICATOR. Henry A. House, Bridgeport, Conn. Filed May 2, 1905. Serial No. 258,476.

Claim.—1. In an indicator of the character described, a glass tube, flexible reservoirs having open communication with the interior of said tube and at each end thereof, said reservoirs and tube sealed against the admission of air, a casing to form a chamber about each reservoir, one of said reservoirs holding liquid, means for admitting air above the normal into one chamber to force the liquid into the glass, and means to permit the escape of air from the other chamber, for the purpose set forth.



817,797. STRAINER FOR AIR COMPRESSOR. William J. Ogan, Dayton, Ohio. Filed Feb. 1, 1906. Serial No. 298,908.



Claim.—A strainer for air compressors, comprising a screw-threaded apertured base A with yoke D extending from its upper side and spanning the aperture, concentrically-disposed screen cylinders E and J mounted upon said base portion and inclosed at their upper ends by a cap G, a stem C projected from the yoke D and penetrating a central aperture in the cap, said stem being provided with a nut which tightens the cap against the screen cylinders, said screen cylinders providing a chamber concentric therewith and lying on the outer side of the aperture in the base, a filtering medium inclosed within said chamber, and a shield inclosing said strainer and held in position by the nut which tightens the cap against the screen cylinders.

817819. Air Brush. Liberty Walkup, Rockford, Ill. Filed Aug. 18, 1905. Serial No. 274,803.

Claim.—1. In an air-brush, in combination, a tubular body threaded exteriorly throughout a portion of its length and provided with an inwardly-sloping perforated shoulder portion terminating in a neck, a conical plug having a tapering central bore extending longitudinally therethrough and tapped at its base into the free end of the neck of the tubular body, a conical cap having the interior of its larger end portion fitted closely to and slidable upon the unthreaded portion of the tubular body and the interior of its smaller end portion tapered to conform to but not contact the exterior of the conical plug, thereby forming an annular air-chamber between such cap and the neck of the tubular body and the conical plug and means for longitudinally adjusting the cap to the conical plug, substantially as and for the purpose specified.

817,953. Fluid Pressure Brake. Robert H. Blackall, Edgewood Park, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a corporation of Pennsylvania. Filed June 13, 1903. Serial No. 161,296.

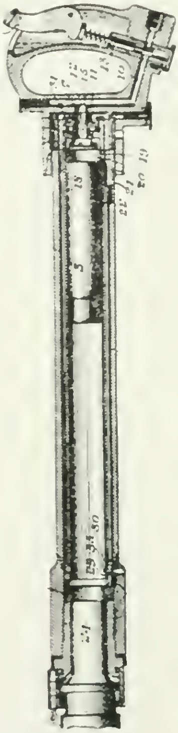
Claim.—1. In a fluid-pressure brake, the combination with a train-pipe, auxiliary reservoir, brake-cylinder, and a triple valve device having means for supplying air from the train-pipe and from the auxiliary reservoir to the brake-cylinder in emergency applications, of means independent of the triple-valve piston for slowly equalizing the pressure upon opposite sides thereof after an ordinary emergency application of the brakes.

818,060. Pneumatic Wheel. Richard Thew and Hollis H. Harris, Lorain, Ohio. Filed Dec. 19, 1904. Serial No. 237,391.

Claim.—1. The combination of a sleeve adapted to surround the axle, an annular member mounted on said sleeve, a cushion on said annular member, a wheel having a hollow casing surrounding said cushion, a collar on the axle bearing against said sleeve and holding said annular member in place, and means for holding the collar in place.

818,037. Starting Mechanism for Pneumatic Tools. Robert T. Mickle, Philadelphia, Pa., assignor to Ridgely and Johnson Tool Company, a corporation of Illinois. Filed Sept. 6, 1901. Serial No. 74,529.

Claim.—1. In a pneumatic tool, a cylinder having exhaust ports, a piston therein, a normally open stop-valve contained in said cylinder, and means for closing said stop-valve, and starting said piston when the working tool is pressed to the work.



818,155. Air Brake Coupling. John S Farlow, Salisbury, Md. Filed Oct. 27, 1905. Serial No. 284,728.

Claim.—1. The combination with a car, of brackets secured thereto in spaced relation longitudinally of the car, a sleeve slidably engaged in the brackets and extending beyond the end of the car, a hollow resilient body carried by the outer end of the sleeve, said body having an opening in its outer portion and having another opening communicating with the passage of the sleeve, a collar carried by the sleeve between the bracket and arranged for engagement of the outer bracket to limit the outward movement of the sleeve, a spring disposed between the collar and the inner bracket to hold the sleeve yieldably against inward movement, a turn plug carried by the rearward end of the sleeve, means for automatically operating the turn plug when the sleeve is moved, a fluid supply pipe, and flexible connections between the turn plug and said supply pipe.

818,200. PNEUMATIC TYPEWRITER. Maximilian Soblik, Dusseldorf, Germany. Filed Nov. 16, 1903. Serial No. 181,292.

818,320. FLUID PRESSURE BRAKE AND OTHER APPARATUS. James N. Weikly, Jersey City, N. J., assignor to George Holt Fraser, Brooklyn, N. Y. Filed Dec. 10, 1896. Renewed Oct. 10, 1905. Serial No. 283,500.

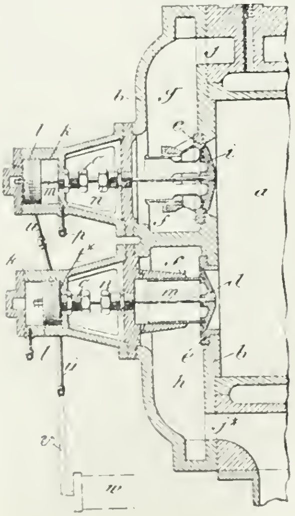
Claim.—1. In air brakes and other pressure apparatus, the combination with a source of fluid pressure, means for utilizing such pressure, a pipe communicating between said parts and a valve controlling such communication, of a pressure regulator in communication with said pipe beyond said valve and automatically preventing flow of pressure to said means exceeding a predetermined limit, and a valve operated by said regulator, having fully open and fully closed positions and popping from one position to the other without intermediate rest.

818,321. PNEUMATIC MATTRESS, CUSHIONS, &c. Richard A. Whall, Reading, Mass., assignor of one-half to Metropolitan Air Goods Company, Reading, Mass., a corporation of Massachusetts. Filed July 22, 1905. Serial No. 270,832.

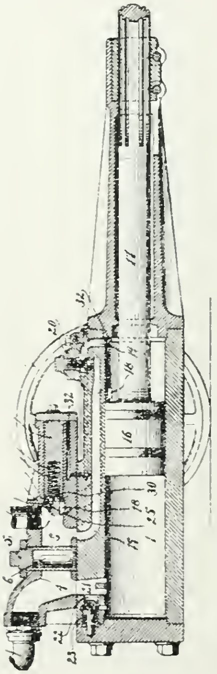
818,402. PNEUMATIC-TIRE PLUG. DAVID APSTEIN, Bridgeport, Conn. Filed June 24, 1905. Serial No. 266,863.

818,567. VALVE-OPERATING DEVICE FOR COMPRESSORS. HENRY C. SERGEANT, Westfield, N. J., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed June 26, 1902. Serial No. 113,342.

Claim.—1. The combination with the inlet-valve of a compressor, of a motor consisting of a cylinder and piston, means for admitting a pressure fluid to said cylinder on one side of the piston for closing said valve, and an elastic-fluid supply connected with said cylinder on the other side of said piston and exerting a constant tendency to open the valve, substantially as herein described.



818,619. COAL-CUTTING MACHINE. ARTHUR H. GIBSON, Easton, Pa., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Nov. 15, 1905. Serial No. 287,401.

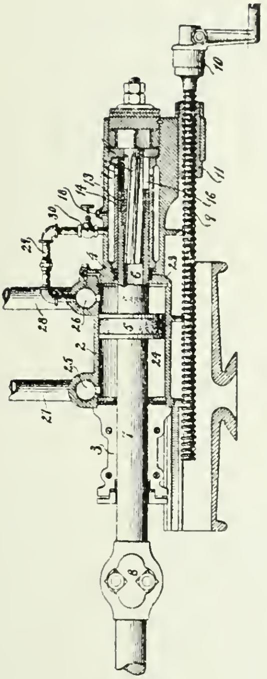


Claim.—1. In an air-presser-driven coal-cutting machine, a work-cylinder, its piston, air-passages leading to the front and rear of the cylinder and a governor controlled by the movement of the piston for reducing the stroke of the said piston.

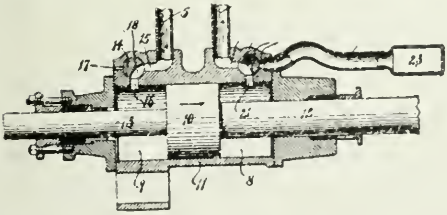
818,649. PNEUMATIC COLOR-APPLYING APPARATUS. FELIX WOLF, New York, N. Y. Filed Jan. 30, 1906. Serial No. 298,731.

818,681. ROCK-DRILL. ARTHUR H. GIBSON, Easton, Pa., assignor to the Ingersoll-Sergeant Drill Compan, New York, N. Y., a Corporation of West Virginia. Filed Aug. 26, 1905. Serial No. 275,851.

Claim.—1. A rock-drill piston having a tail-rod, a cylinder having a tail-rod chamber, and pipes for feeding the motive fluid to the opposite sides of the piston, said cylinder having a passage leading from one of the motive-fluid pipes to the tail-rod chamber.



819,011. ELECTROPNEUMATIC CHANNELER. Arthur H. Gibson, Easton Pa., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Dec. 15, 1905. Serial No. 291,842.

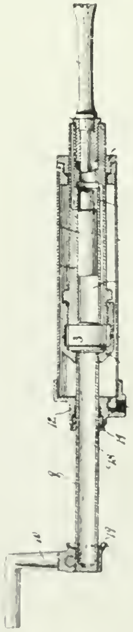


Claim.—1. A tool-piston, its cylinder, pipes for supplying motive fluid alternately to the opposite sides of the piston and means for closing communication between the space at one side of the piston and one of the pipes and opening the said space to atmosphere.

818,776. SAND-BLAST APPARATUS. John D. Murray, San Francisco, Cal. Filed May 5, 1905. Serial No. 258,965.

819,032. FLUID-PRESSURE BRAKE. William P. A. Macfarlane, Chicago, Ill. Filed Nov. 4, 1905. Serial No. 285,822.

818,638. HAMMER-DRILL. William Prellwitz, Phillipsburg, N. J., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Dec. 7, 1905. Serial No. 290,690.



Claim.—1. In a hammer-drill, a hammer-cylinder and a hollow protective casing therefor having its walls entirely spaced from the cylinder, the cylinder being supported only by the ends of the casing for the purpose set forth.

Office
CHIT-CHAT

¶ Most men—that is, real men—no matter what their regular vocation may be, are interested in knowing "how it's made", whether "it" be a toothpick or a magazine dealing with a technical subject.

¶ The why and wherefore of any product of the hand and brain of man is as interesting, in its way, to the user as to the maker. This applies in a marked degree to the man who pays for the product; and especially is it true in the relation between subscriber and publisher.

¶ We shall publish from time to time "Office Chit Chat" in the hope that our readers will use this page as a medium for expressing their commendations, suggestions and kicks to the end that COMPRESSED AIR may embody as far as possible the ideas of usefulness suggested by those who with ourselves, are most vitally interested in maintaining a clearing house of useful compressed air information.

¶ Perhaps you say "There are too many technical papers. I subscribe to two or three and while interested in pneumatics, I am not sufficiently benefited by receiving a waste basket full of papers every month." You are right—that is, half right. There are more technical papers published than can be properly digested, but there is no paper dealing with the subject of air under pressure except COMPRESSED AIR, an established paper entering its eleventh year.

¶ "I came like water and like wine I went," said Omar Khayam—and he *might* have said the technical papers come like water. They pour in—they stream in—papers devoted to civil engineering, mechanical engineering, electricity, water, gas, building, machinery, brewing, tanning, and so on, ad infinitum, good in their fields but in fields that look upon compressed air as an incident; and in most of these papers are continually appearing practical articles and paragraphs on compressed air.

¶ But how is the engineer, say at a mine power house, going to keep pace with compressed air?—By reading all the journals and clipping out the compressed air articles? If he did the mine wouldn't get much of his time.

¶ If he is up against a difficulty—a really tough one, what paper can he write to for help? He can write to any paper, but WHAT PAPER CAN ANSWER A DIFFICULT COMPRESSED AIR QUESTION?

¶ "Compressed Air Taught by Mail". Did you ever see a correspondence school "ad" that offered to teach compressed air by mail? No. They teach mechanical engineering, electrical engineering, law, acting, locomotive engineering, hydraulic engineering, and what not, by mail, but they side step compressed air.

¶ Why?

¶ Because the men who KNOW anything about the subject are not teaching school. They are a comparative few and they are snapped up by the compressed air machinery manufacturers and set to work learning the practical side of the subject—which doesn't always coincide with theory.

¶ "Compressed Air" is edited by graduates of engineering schools who have served their time in overalls and worked and fussed and lived with air compressors, drills and pneumatic tools. They are theoretical men—who know when to cut out theory and substitute the knowledge gained by rough and tumble experience.

¶ "Compressed Air" takes from the hundreds of engineering and technical papers the matter pertaining to the subject, digests it and serves it up either straight or with remarks on the side—the information and clippings come to us like water—and like wine they go, concentrated, and in a selected form, with a clear and legible label.

¶ We don't know it all—and for this reason we are making a point of our correspondence columns so that we can swap ideas with the man on the job—so that we can answer a letter by printing it, even if it brings forth a storm of contradictory evidence. The more contradictions and disagreements the better for the man who runs a compressor or drill—for there can be but one "right" in an argument, and discussion and controversy will boil down the facts until the "right" is proved.

COMPRESSED AIR
Established 1896.

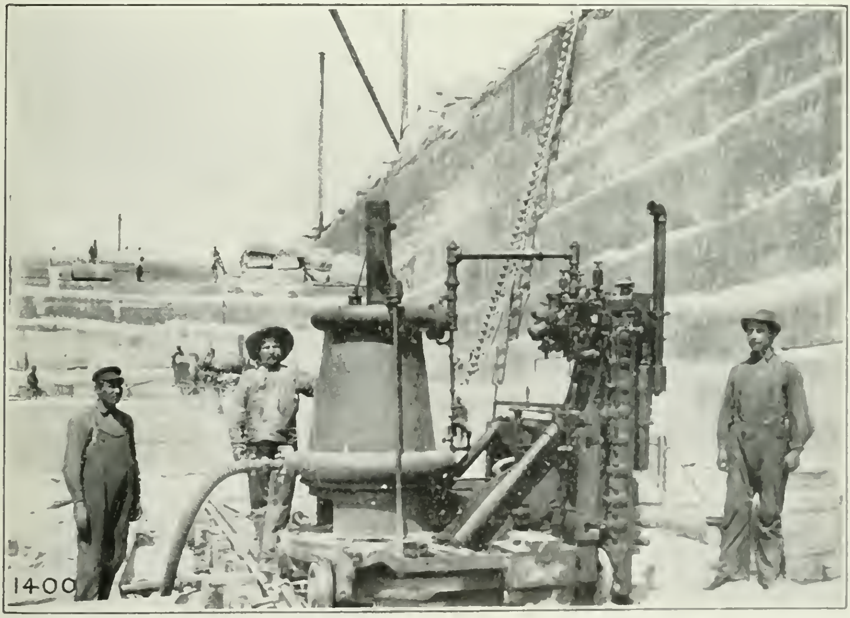
A monthly magazine devoted to the useful application of compressed air.

JULY, 1906.

IMPROVEMENTS IN THE CHANNELING MACHINE.

Written for COMPRESSED AIR

Like all other labor saving machines, the channeler has been undergoing constant improvement and remodeling until the modern machine represents practically a new design from the rails up. Not only have high power and cutting speed been secured, but endurance and reliability also have been developed in the newer models. Another and most important point—economy of fuel—has been carefully studied with the result that compressed air is now being largely adopted as the motive power and air re-heaters are replacing the boilers on machines in the more up-to-date quarries.



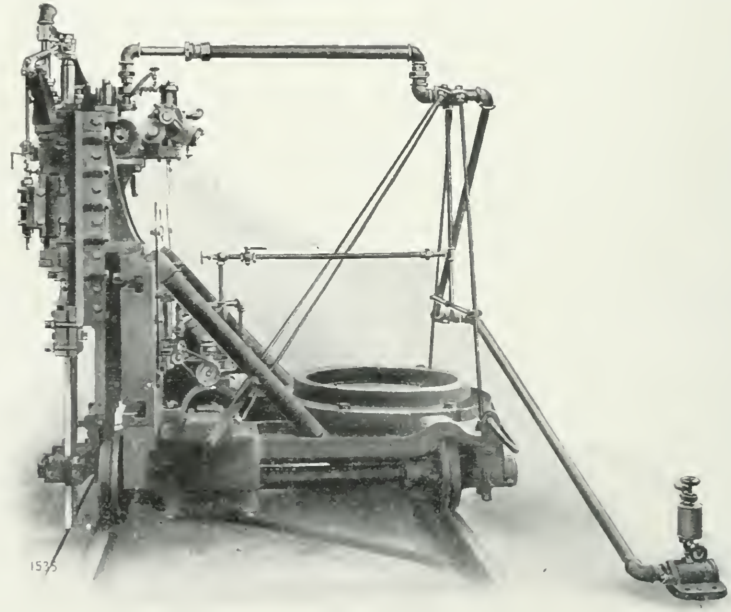
DIRECT ACTING CHAMBER FITTED WITH AIR REHEATER.

It is of more than passing interest to hear that the Cleveland Stone Co., is replacing its Wardwell Type of Channelers with the new Ingersoll direct-acting type operated by compressed air. As all quarrymen know, the Wardwell was the original type of channeling machine and has many friends in consequence, but, as improvements have been made in the direct-acting type, these friends have gradually come to see that the Wardwell isn't the best design. The chief stronghold of this machine has been in connection with sandstone work. Here the bits wear rapidly, due to grit, and "lose their gage" as it is called, it being common for steel working in cuts of only 6 to 8 inches in depth to lose as much as a half inch of their gage. As the cuts are made from 6 to 10 feet deep, this means that there is a great deal of reaming in sandstone, *i. e.* the bits must be dressed out nearly to their original width and then the cut reamed or widened out by brute force. This is very severe on a channeler machine

Another feature, not confined, however, to sandstone, is the existence of what the quarrymen call "pressure," *i. e.* when channeling has progressed to a certain depth, generally to a bed, the rock may crush together, thus partly or entirely closing up the channel

The powerful lever operation of the Wardwell type is such that it has great capacity to ream and handle this "pressure," and it has always been contended, therefore, that this was a field for which direct acting type of machine was not adapted because the entire power of this style of channeler is similar to that of a rock drill and consists of a simple and direct pull of the steam pressure on the piston.

To some extent this criticism was true; but, as the direct acting type has been improved and made more powerful, this feature has been overcome, until now the direct-acting type may be considered a standard for all classes, not excluding sandstone, and its superiority has been undisputed in the marble and limestone quarries for many years.



ILLUSTRATING METHOD OF MAKING AIR CONNECTION.

Two years ago the Cleveland Stone Co., who operates some 35 quarries in Ohio and other States, mostly sandstone, and who used from 110 to 120 Wardwell machines, put in an Ingersoll 8 inch track machine of the direct-acting type and a record of its work has been kept ever since. These records show briefly that where the Wardwell machine cuts 174 square feet per day as an average by the month, which includes all lost time, the Ingersoll machine has made runs up to 258, 280, 300, and even 450 square feet per day, averaging 5,500 to 6,000 feet by the month, figured on the same basis.

The Ingersoll cuts so much faster that it takes an extra man to "clean ditch." It takes more power, of course, than the Wardwell, but the net result is that, everything figured in, there is a saving of 3.4 cents per square foot in favor of the Ingersoll machine; or on the above basis, of $7.50 to $9.00 per day; figuring only 200 days per year this means a net saving of $1,500.00 to $1,800.00 per year for each machine. Two Wardwell machines, taking a crew of six men, will average less rock cut than one Ingersoll taking a crew of four men.

This difference in cost is demonstrated by the experience of the Cleveland Stone Co., at their North Amherst Quarry. Here it was found that Bryant or Wardwell channeling machines cut on an average of 2,000 feet of stone per month, each requiring one operator and two helpers. As there are 21 of these machines in use, the total channeling done is 42,000 feet per month, costing approximately 5.7 cts. per foot, or $2,400 per month. A direct-acting channeling machine requiring the same labor demonstrated that it could easily cut an average of 5,500 feet per month and frequently ran over 6,000 feet, making the cost 2.35 cents per foot. In other words, channeling with the direct-acting machines would cost $1,250.00 per month instead of $2,400.00 per month with the old style machines. Account should also be taken of the enormous repair expense connected with the former type of machines. With proper care the direct-acting type should outlive the old-fashioned kind by a considerable margin of time.

One of the features tending to produce the high efficiency of the new type of channeler is the roller guide. By this device the crosshead is dispensed with entirely and a chuck, forged solid with the piston rod, receives the cutting steels. The bits work between two guide rollers of hardened steel, guiding them on all four sides. This releases the machine from the weight of the heavy crosshead and the friction of the steels in the rollers is practically negligible. With this device a split front head is required, held in place by a strong forged steel ring drawn on a taper by cylinder through-bolts. In changing steels, one or two bolts are loosened and the front roller lifted away, when the steels may be cleared. The guide rollers are mounted on a plate which can be raised or lowered on the shell of the machine. The use of the roller guide permits the machine to strike a more rapid blow and increases its cutting power and capacity in material somewhat springy or elastic in nature.

Perhaps the most important step forward, however, in the operation of channelers is the increasing use of compressed air for this purpose. In the earlier applications of compressed air to these machines the boiler was used as a re-heater, but now, re-heaters of special and compact design take the place of the boilers, thus greatly adding to their efficiency and economical operation. In the case of the Cleveland Stone Company, the saving by using compressed air for the operation of channelers is illustrated by the following figures:

	Before using comp. air.	After using comp. air.
Labor and attendance at channelers	16 machines @ $10, $160.	12 machines @ $10, $120.

This reduction in the number of channeling machines is due to the fact that the heavy and uniform air pressure, always available, enables these fewer machines to do more than the work formerly done by the larger number, when operating under the lower and fluctuating pressure of steam. The use of compressed air also permits of generating the entire power supply at a central compressed air power house where the most economical boilers and compressors may be installed, thus eliminating the expensive and uneconomical "temporary" boilers usually found on channeling machines.

A COMPRESSED AIR STONE WORKING PLANT.

We are in receipt of the following letter from James Horne, manufacturer and dealer in marble and granite, at Luverne, Minn. We understood some time ago that Mr. Horne had installed compressed air tools and that the results attained were of more than ordinary interest. We, therefore, wrote him for a description of his plant and a statement of the saving which has resulted from the use of compressed air. In reply we received a letter which we consider of sufficient interest to print in full, as follows:—

To the Editor of COMPRESSED AIR:

DEAR SIR:—"I recently installed an air plant for the operation of pneumatic tools for cutting stone, having previously acquired a Lenox gasoline engine for operating my polishing machine. I purchased a Blaisdell 6 x 6 open-frame compressor fitted with Jarecki unloading device and a 6 ft. by 2 ft. air receiver. These I set up myself with the aid of instructions and blue prints furnished by the manufacturers.

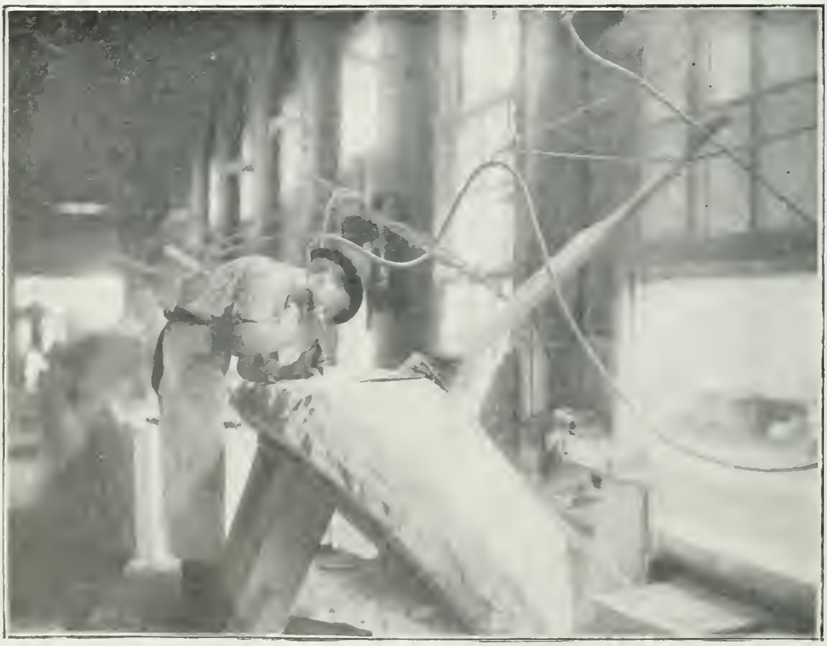
"My compressor has a capacity of 30 ft. of free air per minute when operating at its normal speed of 150 R. P. M., and furnishes sufficient power for 7 hand tools. When using but one or two tools I operate this compressor at 60 R. P. M., which I have found furnishes sufficient air and at the same time saves unnecessary wear and tear.

"I have located my air plant in the basement as by so doing I obtain clean air, free from dust and grit and with very little variation in temperature. Located under the floor is a 6 ft. x 7 ft. cistern for holding the cooling water for the compressor and gas engine cylinder jackets which are piped up in such a way that all drains lead back into the cistern, thus obviating the danger of bursting pipes or jackets in the winter by water freezing in them.

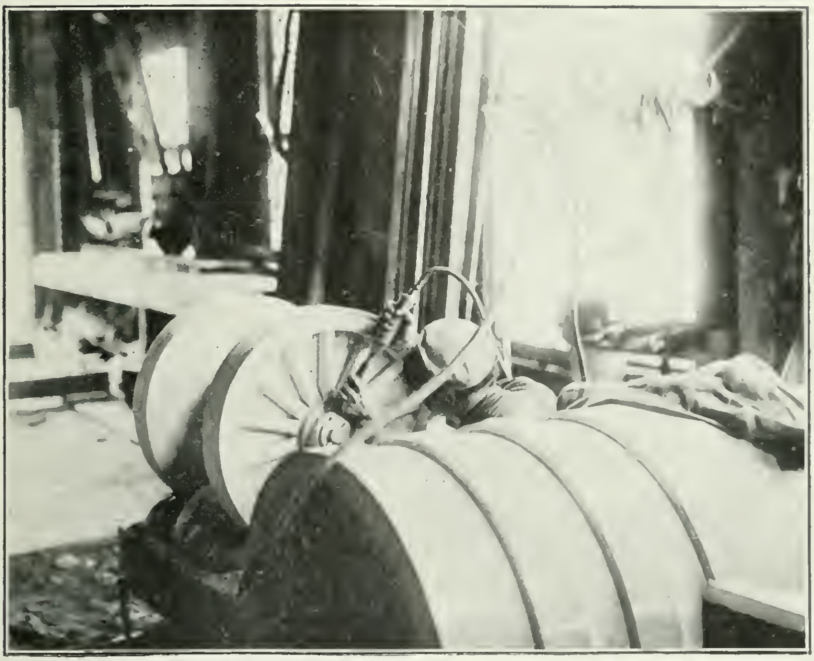
"I used Dallett tools of various sizes and they are giving splendid satisfaction. They are very economical in the use of air as I have operated one ½-inch tool for one hour after the compressor stopped when the pressure gage indicated 78 lbs., the point at which the unloader was set to shut the air inlet, to start with, and it operated successfully till the pressure went down to 40 and even below 30 lbs.

"My limited experience in the use of the smaller hand tools on various kinds of granite, marble and stone have proved to me that they are a great labor saver, especially for tracing granite, in which case one man can do the work of four and do a "smoother" job, than the four could do in the same time by the old method. In cutting the sunk and raised leters, margin lines, chambers and other light work, the saving is just about one half compared with the old process.

FINE CARVING WITH AIR TOOLS.



ROUGHING OUT THE WORK.



AIR TOOLS ON MONUMENT WORK.

PUTTING ON THE FINISHING TOUCHES.

"This is only my individual and rather limited experience, but others, of course, are likely to come to different conclusions, according as they are more or less adaptable to modern methods of doing the same old work.

"One little trouble I experienced from the start, I will relate, as it may meet the eye of some other monument man who runs a tool himself and who also finds it to his interest to be able at any moment to present himself neat and clean in appearance in his show room, especially if he be a single man and his visitor a beautiful, fastidious and rich young widow, whom he wishes particularly to land for a good order, not to mention more lofty aspirations. The tool would sputter an oily liquid over everything in its immediate vicinity when in operation. I obviated this by cutting down the supply of oil to the cylinder of the compressor and opening the drain cock at the bottom of the receiver every night at quitting time and leaving it open for a minute next day after starting up. It is surprising the amount of water that forms in compressed air in a day's run.

"Yours truly,
"JAMES HORNE,
"Luverne, Minn."

COMPRESSED AIR AS A MOTIVE POWER IN THE QUARRY

BY GEO. H. GILLMAN.*

Compressed air to the average mind conveys rather a vague meaning which ranges from the paper bag blown up by the child, with a view of producing a report by suddenly bursting it, to the motive power of some of the largest traction engines which are supplied with air up to 3,000 pounds pressure per square inch.

At first thought it appears strange that the air which we breathe and which possesses in its natural state neither power nor energy, is by its agency revolutionizing the quarry industry in all quarters of the globe. Although dating back as far as 1556 we have records of compressed air being used as a means of mine ventilation; it is only during the past few years that it has become recognized as a main quarrying power, except perhaps as a motive power to operate the reciprocating piston type of rock drills, which application dates back to the excavation of the Hoosac tunnel.

To-day there is hardly any mechanical device used in the quarry which has not been successfully operated by compressed air, and new applications are being found for it every day which are surprising in their number and variety. It is true that its adoption has been slow, which is due to the fact that quarry owners as a rule have been educated in the practical school of experience, and their methods have not afforded a great opportunity for experimenting. The air compressor, which has justly been termed the heart of the plant, is made in a great many different forms, but the most commonly adopted at the present day, consists of a reciprocating piston in a cylinder provided with heads in which are valves so arranged that when the piston moves on its rearward stroke air is sucked in filling the space between the cylinder head and the piston with air at atmospheric pressure. When the piston advances on its forward stroke this air is compressed between the piston and the cylinder head and is forced out through an independent set of valves, commonly termed outlet valves, which are in direct communication with the receiving tank from which it is conducted by pipe and hose line to the work.

Any form of power available may be used to operate the compressor. The most common forms used are steam, electricity and water. All of these in the past have been rivals of compressed air, but to-day they content themselves by working hand in hand with this master power for a common object, and their place in an equipment of an up-to-date quarry is as a generator of power in the central plant rather than as a motive power at the work. It is true that the advantages of compressed air have been long recognized, and it is also true that these advantages until recent years were only gained at high expense, but in a modern air plant these old theories of loss and efficiency have been exploded as in the plant of the Cleveland Stone Co., at North Amherst, Ohio, where for a number of years the machinery operated in this plant required forty-nine separate steam boilers aggregating 2,000 horsepower. They now have a central compressed air plant operating the independent machines with air instead of steam and requiring only 750 horse power to operate them all. These machines operating by air consist of reciprocating rock drills, plug drills, channeling machines, hoisting engines, pumps, Corliss engines, grindstones, lathe engines, steam hammers, sawmills and other devices; in fact every mechanical contrivance in use on their quarries. Air is distributed from the central plant over a large area, and supplies motive power to operate three different quarries and several mills, and the fact is that this plant is consuming but one-fourth the fuel which was formerly spent for a given duty.

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*Railway Exchange Building Chicago.

One of the greatest drawbacks heretofore met with in the operation of a compressed air plant and one which has been a bugbear in the minds of those contemplating the installation of such a plant is the matter of freezing. The presence of moisture in compressed air is an unavoidable condition, existing in the atmosphere at all times in greater or less quantity. When air is compressed the moisture is consequently carried with it, and when the air is expanded in the cylinders of the drills and tools while doing its work, cold is produced as the pressure falls and the latent heat of compression is taken up. Consequently the moisture contained in the air is changed into frost, which accumulates in the exhaust passages and retards the action of the tools. There have been several ways and means devised for preventing trouble in this direction.

The first of these and perhaps the most satisfactory, is to eliminate the moisture from the air after it is compressed and before it enters the pipe line. This is best accomplished by an after-cooler, placed between the compressor and the receiving tank. Such a device consists of a tank containing a number of tubes placed closely together (an old boiler will sometimes make a very effective cooler) through which water circulates. The compressed air enters at one end of the after cooler and passes several times around the tubes by suitable baffle plates placed in such a manner that the air is broken into thin layers, and traverses the entire length of the tank a number of times before it enters the pipe line from the opposite end to that which it entered.

Too much cannot be said in order to have the pipe line of ample size. Air in passing through pipes is subject to a loss in pressure due to friction against the walls, and obstructions in the line; hence it should be borne in mind by parties contemplating the installation of a compressed air plant, to have the line as free from obstructions as possible with the least number of turns possible and the pipe line of ample size.

The second advantage lies in economy of power at the compressor. The effect of temperature upon volume of air is to increase the volume or, if the volume of air is confined in a given space, the effect would be to increase the pressure. As we expend work upon air either by heating or compressing it, we thereby endow it with energy which it may part with later in doing work, but it might be best stated that it pays to put energy into the air by reheating it only when the air is applied to do the work immediately. Otherwise, energy imparted to the air by the application of heat would be lost by radiation and conducted to neighboring bodies.

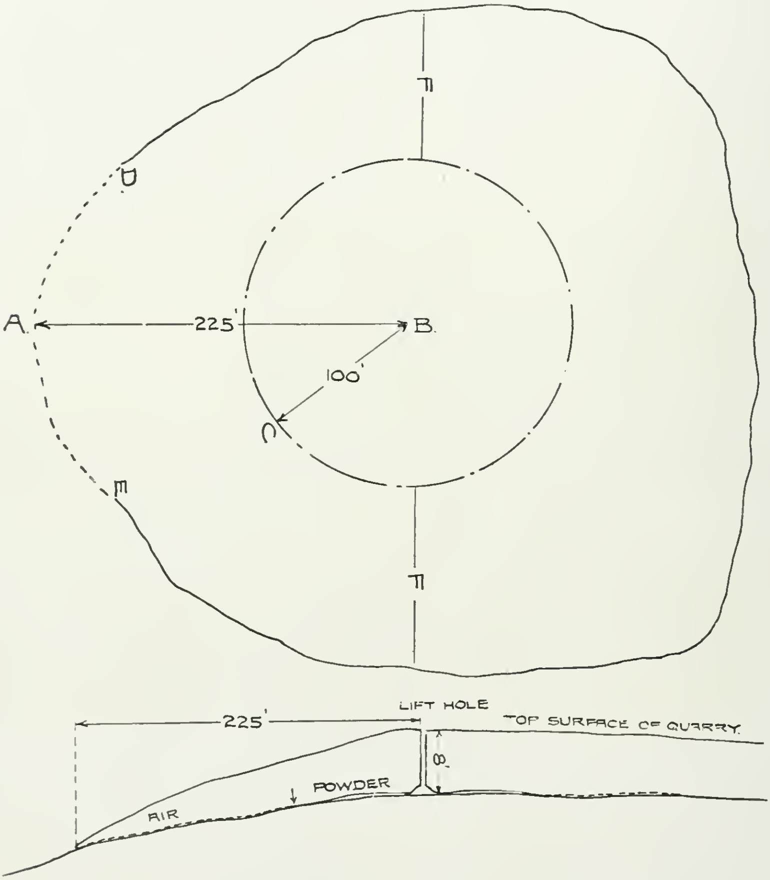
At low pressure a greater volume of air is required to furnish a given power than at high pressure, and in this advanced age where the pass word of the quarry as well as in other spheres of life is "hustle and get there" the tendency has been to increase the pressure so that the tools may be worked to their full capacity. One hundred pounds per square inch is a common pressure to be found in the up-to-date quarries, while some operators prefer even higher pressure, and it is not an uncommon occurrence to see the gauge arrow pointing to the 125 lb. mark. Builders of pneumatic appliances are falling in line and constructing their machines with a view of accommodating this increase of pressure, and parties contemplating the installation of a compressed air plant should invariably consult the builders of the machines to be used, who will be only too glad to give them the advice of their experience, which must necessarily have been varied in this particular line.

COMPRESSED AIR IN A GRANITE QUARRY.

A most interesting application of compressed air has recently been inaugurated at the quarry of the North Carolina Granite Corporation, at Mt. Airy, N. C. It consists of the cleavage of granite by means of compressed air in the faces or ledges of the hill-side upon which the quarry is located. The property covers an area of considerable extent, consisting of a perfectly solid, homogeneous mass of moderately hard granite which shows no ledges or bed planes whatever, but splits readily in a straight line in almost any direction. In order, therefore, to operate the quarry upon the most advanced and economical principles, advantage has been taken of the ease with which this stone may be split, and artificial ledges have been made to which the work may be carried from the surface. Large sheets or laminations of granite are separated from the hill by the combined use of powder and compressed air. The stone is then split into suitable sizes for building material, paving blocks, curbing, lintels, and stock, for monumental work.

In the center of the sheet or area to be lifted, a 2 or 3-in. drill hole is sunk to a depth of 6 to 8 ft., depending on the maximum thickness of stone required. The bottom of this drill hole is enlarged into a pocket by exploding half a stick of dynamite. A small charge of powder, about a handful, is then exploded in the pocket, resulting in starting a horizontal crack or cleavage across its greater diameter. Charges increasing in size are then exploded in the cavity, the drill hole being plugged for each blast to confine the powder gases and thus exert a more or less constant force upon the stone.

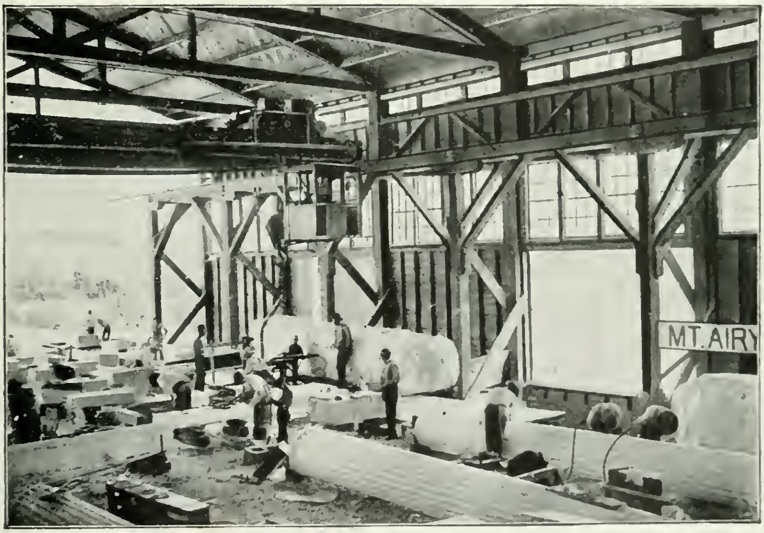
After the cleavage has extended to a radius of 75 or 100 ft. in all directions from the lift hole, a pipe is cemented into the latter and connected by a globe valve to a pipe line from an air compressor. Compressed air at 70 to 80 lb. pressure is gradually admitted through this connection causing the cleavage to be rapidly extended until it comes out on the hillside in a thin edge down hill from the lift hole. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarrymen can work, thus securing from different parts of the sheet stone of any required thickness.



Key:—B–Lift or Drill Hole; BC–Area Cleaved by Powder; AFF–Area Cleaved by Compressed Air; DE–Thin Edge on down hill side of Quarry where Air Escaped.

This method was not perfected in a day, but is a gradual development of methods previously employed in the same quarry. For a number of years the practice of splitting ledges in the same manner with powder only, as followed in quarries in the Lithonia and Stone Mountain districts of Georgia, was used in this quarry. This system, however, was not entirely satisfactory. The amount of powder required is necessarily considerable, and the time required for splitting a large area of granite is quite long, since unless reasonable care is taken and time is afforded for the stone to split gradually by natural expansion and contraction, the force of the explosion brings the cleavage abruptly to the surface.

Some time ago, water under pressure was substituted for powder in the quarry after the cleavage had extended some little distance from the drill hole. This method was found to be an improvement over the use of powder only, but was surpassed in economy and convenience by using compressed air after the company installed a new Sullivan air compressor last season. When the compressed air was first tried, the full pressure of 80 lb. was admitted into the cavity, which had previously been extended some 75 or 100 feet from the lift hole. The power of the air was too great, however, for the character of the stone, causing the cleavage to turn abruptly to the surface. A new drill hole was sunk in another part of the quarry, and the cleavage started by powder in the same manner as before. The compressed air pipe was then attached again and the air admitted very gradually. The stone could soon be heard cracking in all directions and in about half an hour the cleavage came to the surface on the hillside some 225 ft. down-hill from the lift hole. The time required for extending the cleavage by powder for 100 feet was between two and three weeks, while to split a larger area to the radius of 225 ft. required only half an hour when compressed air was used.



INTERIOR OF CUTTING SHED.

The accompanying sketch or plan shows the area covering nearly 2½ acres, lifted by this means. Only a portion of the cleavage extended to the surface, owing to the thickness of the sheet on the up-hill portion of the slope. The ledge or bed plane thus formed was reached by quarry bars and drills in the usual manner. It is believed that this is the only quarry where compressed air is used to split granite in this manner, and it can readily be seen that the method affords a great saving of time and expense.

The granite for many building and paving purposes is produced by this and other economical methods of operation at a price comparing favorably with the cost of production in any quarry in the country The equipment of the quarry is modern in every respect, including 35 plug drills, 3 Sullivan tripod drills, 4 Sullivan quarry bars, 15 surfacing machines and 60 small hand tools. These are all operated by air power from a Corliss air compressor, furnished by the Sullivan Machinery Co., of Chicago. This compressor is of the two-stage type, with a piston displacement of 2,000 cu. ft. of free air per minute when operating at 78 r.p.m. against 80 to 100 lb. terminal pressure. The steam cylinders of the compressor are 16 and 28-42-in., and the air cylinders 16 and 26x42 in. Semi-rotary or Corliss air inlet valves are used actuated by separate eccentrics on the engine shaft. They are of relatively large diameter and remain open during the entire stroke, but close very quickly. The poppet air discharge valves are in the cylinder heads, and act in a direction parallel with the piston rod. The air supply is drawn from outside the engine room insuring colder, cleaner and drier air. The air cylinders and cylinder heads are water-jacketed, and there is a large receiver-intercooler between the high and low-pressure air cylinders. The steam end is a Sullivan heavy-duty Corliss cross-compound condensing engine, to the rear of which the air cylinders are coupled in tandem. All cylinders, both steam and air, are made with loose liners, forced into the cylinder castings by hydraulic pressure A steam receiver and reheater is situated between the high and low-pressure steam cylinders, below the floor line

The quarried stone is handled from the quarry to a 65x300-ft cutting shed, or to cars on a railroad track, by nine cableways An incline is also provided for loading rough stone for shipment. The engine room, offices and cutting and finishing sheds are of modern design. The boiler and engine house is 112x53 feet, and contains two Heine 210 h. p. water tube boilers, a 150 h. p. Ideal compound engine coupled direct to a 100 k. w. Bullock generator, and the air compressor above described. The cutting shed is 360x65 feet in size. Stock is handled by a 20-ton Pawling & Harnischfeger electric crane, with a 5-ton auxiliary hoist.

PNEUMATIC COAL-BORING MACHINES AND TOOLS.*

BY W. LYNCH.

I have been told by mining engineers in the South Staffordshire district that a rotary power-drill was wanted, as the material in which the holes were drilled when driving headings, etc., was too soft to admit of the use of the percussion type of drill, and the tool became clogged. Some three years ago, therefore, I experimented in one of the mines with an ordinary pneumatic drill as used in boiler-works, but was not successful, because the feeding had to be done by hand.

Pneumatic tools may be divided into two classes, namely, rotary and percussion-rotary machines. The latter, which gives a percussion-blow, are used for chipping, calking, rivetting, etc.

LITTLE GIANT AND WHITELAW MACHINES, FITTED WITH ROCK AND ORE-BORING ATTACHMENT.—The Little Giant and Whitelaw piston air-drills are of a rotary type. They are probably well known to some of the members in their capacity of metal and wood-boring machines, but the application of the rock and ore-boring attachment has converted them into valuable machines for the quarry-owner. They will drill holes up to 2 in. in diameter, in hard iron ore and similar material, at the rate of 3 ft. per minute, the maximum depth attained, without shifting the bit, being 6 ft. The total weight of the heaviest machine being about 50 lb., all sizes can be readily set up and operated by one man.

The rock and ore-boring attachment consists of a split nut, of simple and efficient construction, and the halves are readily replaced when worn out. When drilling, the links connecting the halves of the nut are locked, and the nut can be opened by one movement of the links so that the screw-bar can be at once withdrawn and the drill-bit changed. The best results can be obtained with air at a pressure of 80 to 100 lb. per sq. in., but the machines can be operated with 50 lb., the air-consumption at the lower pressure being about 20 cu. ft. of free air per minute.

LITTLE GIANT AND WHITELAW ORE-BORING MACHINES, FITTED WITH RE-FEED.—These machines are similar in character to the split-nut type, but are fitted with several novel and important details, by which, in the event of the drill-point meeting an obstruction, the drill will be automatically withdrawn for about 2 in. and then re-fed forwards, the whole of the operations taking place automatically, with the motor continuously in the forward direction. The resistance at which the slip will take place is readily adjusted to suit varying conditions and circumstances. In this type of machine, the piston air-drill drives a quick-pitch screw-bar by means of a train of differential gears, which can be varied to give any range of feed required from 1-12 in. per revolution. This is an important feature, as the slow feed is obtained in conjunction with a screw of coarse pitch, so that, by operating the lever controlling the clutch-gear, the screw-bar and the drill-bit are withdrawn at a rate equal to the pitch of the screw. The weight of the complete machine is about 60 lb., and it will drill holes 2 in. in diameter at the rate of 3 to 4 ft. per minute.

At some ironstone mines, in the Cleveland district, the No. 8 Whitelaw machine drilled 40 holes, 1¾ in. in diameter, per shift, obtaining 66 tons of material, or an average of 1 ton 13 cwt. per hole, the air-consumption per minute, at a pressure of 50 per sq. in., being 20 cu. ft. Two of these machines, when obtaining an average of 132 tons per shift with a total air-consumption of 40 cu. ft. of free air per minute, kept 13 men fully employed. Comparing the work done by two Whitelaw machines with that accomplished by another type of pneumatic drill in use at these ironstone mines, it was found that the two Whitelaw machines were capable of doing one-third more work. Further, while one man could lift the Whitelaw machine with ease, the other machine, on account of its great weight, required a horse, as well as a man and a boy, to move it from one part of the mine to another.

At Cowpen colliery, near Newcastle-upon-

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*A paper read at a meeting of the Institution of Mining Engineers, at Birmingham, February, 1905.

Tyne, with a No. 1 Little Giant drill, with the ore-boring attachment, having a feed-screw of 5 threads to the inch, a hole was drilled in stone to a depth of 2 ft. 10 in., with drills 1¾ in. in diameter, in 3 minutes 36 seconds, including the time occupied in changing the drills. A hole of similar length is drilled by hand in 20 to 30 minutes. In coal, a hole was bored by the machine to a depth of 3 ft. in 2 minutes 50 seconds, including the time occupied in changing the drills; the same work, when done by hand, occupies about 10 minutes.

THE BOYER HAMMER WITH A ROTATING DEVICE.—This machine, designed for various classes of plug-and-feather work, is in use in the majority of the leading quarries throughout Great Britain. It is made in three sizes as follows: 1 1-16 in. by 4 in., adopted for light drilling; 1 5-16 in. by 1½ in., for medium drilling; and 1 5-16 in. by 3 in. for heavy drilling. The best results are secured with an air-pressure of 80 lb. per sq. in., and the hammers consume approximately 20 cu. ft. of free air per minute at this pressure. The A type has an automatic rotating attachment; and the B type has a rotating attachment operated by hand, the tool used being an improved type of the well-known No. 1 Boyer chipping-hammer. The light weight of these machines admits of their being easily held by hand, and they are therefore successfully utilized for either top or side-line work.

On account of the light, rapid blow employed, the drills used with these machines do not require sharpening so frequently as hand-drills; and 20 holes have been drilled with one of these machines, without re-sharpening the drill-bit. The nose of the machine is constructed for the use of standard ⅝-in. quarter octagonal steel-drills, thereby effecting a considerable saving in the time and expense of making drills.

On one occasion, 131 plug-holes, ⅝-in. in diameter by 3 in. in depth, were drilled in hard granite with one of these machines in 140 minutes, including the lining, changing of drills, etc. In a limestone pit, this tool has drilled a hole 1¼ in. in diameter, 2 ft. 2 in. deep, in 35 minutes.

HAND ROCK-DRILL.—The hand rock-drill is adaptable for use either by hand or with a tripod, and its light weight, rapid stroke, compactness and economy in air-consumption give it a great advantage over other machines of this class. The device for freeing the hole from borings is a tube, which envelops the drill-bit, and by means of a blast of air running through it the hole is completely cleared of all obstructions. This arrangement is valuable in cases where the class of rock that is being drilled does not necessitate the use of water. A water connection, using hollow drilled-steel, can be fitted when required. The machine, made in two sizes, has a stroke of 2½ in., and drills holes 1 in. and 1¾ in. in diameter, with a consumption of 30 and 45 cu. ft. of free air per minute respectively, at an air-pressure of 80 to 90 lb. per sq. in.; and the drills weigh 25 and 45 lb. each respectively.

In limestone quarries, these drills are capable of boring holes 1 in. in diameter and 2 ft. deep in 16 minutes. The drill can be used in any direction, either horizontally, vertically or overhead. In a quarry in Wales, holes 1 1-16 in. in diameter and 7 in. deep were drilled into Pennant Rock in 4 minutes; and the hose used for conveying air for blowing the dust from the holes was worked successfully. With these drills, a hole, ⅝ in. in diameter, can be drilled 5 in. in granite in 1 minute, and this speed can be kept up all day.

The drills have also been used in removing the concrete foundations, preparatory to the erection of the Ritz Hotel, in Piccadilly, London, where, in excavating the site, the contractors unexpectedly came upon an old raft of concrete belonging to the buildings formerly on the ground. This was 3 ft. thick, but it was readily removed with little difficulty, with the aid of these drills. Cartridges, with small charges of explosives, were used for blasting, to avoid any danger of disturbance, and the concrete was broken off in small lumps, easy to handle.

CONCLUSION.—There is, in my opinion, larger scope for the use of rock drills in this country than has up to the present been realized; in many of the slate and stone quarries the old system of hand drilling is still in vogue, and even where machine drills have been adopted, they are frequently found to be of old design and often discarded, no attempt being made to keep them in working order, or to replace them by modern machines

A HIGH PRESSURE GAS DISTRIBUTION SYSTEM*

There is in this country a growing tendency to distribute gas at high pressure for considerable distances, and one of the largest systems of this kind is that operated by The Western United Gas & Electric Co., having its headquarters at Aurora, Ill. This company serves about 19,600 consumers in 25 cities, towns and villages, by means of pipe lines aggregating 431 miles in length. These towns have an aggregate population of 140,000 and the extreme distance between them is 52 miles. The gas is used for domestic heating, lighting and cooking; but also to some extent for street lighting and for power purposes, driving gas engines, etc. The accompanying map shows the routes of the pipe lines with their sizes and lengths. For particulars respecting this system we are indebted to Mr. H. L. Rice, general manager of the Western United Gas & Electric Co., and we have also drawn part of our information from a paper read by him before the American Gas Light Association. Mr. P. O'Malley is Superintendent of the Works, and Mr. Howard G. Stillson is Superintendent of Distribution.

In 1902 the Aurora Gas Light Co. built a line 12 miles long, running north in the Fox River valley and serving four towns; in 1903 the La Grange Gas Co. built a line, and these have been connected up and extended by the present company. There are now about 100 miles of high-pressure main pipe line, 286 miles of low-pressure mains, and 45 miles of direct high-pressure distributing mains. The high-pressure pipes are of steel, with screw joints, and range from 8 ins. down to ¾-in. diameter. The low pressure pipes are of cast iron for diameters of 16 ins. down to 3 ins., the smallest low-pressure pipes being 2 in. steel distributing mains. The long-distance mains are generally laid along the roads, in which case the company has to obtain the frontage consent on one or other side of the road. In a few instances the mains are laid across the fields, and in this case special arrangements are made with the owners of the land. The arrangements vary, but provide that the pipe may remain where located for a term of years, during which period the company may have access to it for repairs. The high-pressure lines are tested during construction to 60 or 70 lbs. pressure by compressed air; they are laid in trenches about 30 ins. deep, and there has been no trouble from condensation in these lines.

The gas pressure is 30 lbs. per sq. in. in the long-distance lines, while for the distribution systems of the towns it is reduced to about 3 ins. of water. The district governor used is that of the Johnson-Reynolds Co., of Anderson, Ind. The same company's regulator is used where the high-pressure gas is delivered directly to the consumer's house. Beyond this is the ordinary type of house meter, but between the regulator and the meter there is provided a safety blow-off in the event of the pressure creeping up.

About 20% of the consumers are dependent entirely upon this system, and when the manufacture of gas is ultimately concentrated at one station at Joliet, as noted below, all the other cities and towns mentioned will be dependent upon this system. The annual consumption of gas is about 550,000,000 cu. ft. per year, of which the towns dependent on the line represent a large proportion, although many of them are still in process of development as gas-consuming territory. The high per capita consumption of gas in the suburban towns is indicated by the following statement:

Hinsdale (district governor station), with a population of 3,100, contains about 600 houses, has 554 gas meters and consumes 15,750,000 cu. ft. per year. Western Springs (direct high-pressure), with a population of 750, contains 140 houses, has 126 meters and consumes 3,430,000 cu. ft. The possibilities of high-pressure work in small towns are shown by Plainfield, a farming town of 1,000 population, with about 195 possible consumers. It was piped in 1905 with 1-in. and ¾-in. pipe, radiating from the central trunk line, at a total cost of only $1,290, and already has 150 consumers. As an example of the larger towns, Aurora (population 30,000), has 5,000 consumers, using 125,000,000 cu. ft. of gas.

The gas is generated by works at four points. Coal gas plants at Joliet, Elgin and La Grange pump their surplus gas into the pipe line, and at Aurora there is a combination coal gas and water gas plant which delivers gas to the pipe line or draws from the line, according to the pressure conditions. The plants have a total generating capacity of 2,705,000 cu. ft. per day, divided as follows: Joliet, 800,000 cu. ft.; Elgin, 500,000 cu. ft. (and 500,000 cu. ft. of water gas); La Grange, 225,000 cu. ft.; Aurora, 330,000 cu. ft. coal gas and 350,000 cu. ft. water gas. There are gas holder stations of 1,200,000 cu. ft. capacity at Joliet, Aurora, Elgin and La Grange. District governors reducing the pressure in the distribution mains are located at Batavia, Geneva, St. Charles, Hinsdale and Downer's Grove; all the other towns have direct high-pressure in the mains. At each of the four generating stations there is a gas pumping plant, consisting of straight-line compressors operated by steam. These are Ingersoll-Rand compressors, each having a steam cylinder 10 x 14 ins. and a gas cylinder 13 x 14 ins., and with a capacity of 270 cu. ft. of free gas per minute while operating at a speed of 130 revolutions per minute. They can compress gas to a pressure of 40 lbs. per sq. in. when working under a steam pressure of 80 to 100 lbs. There are two of these machines at Aurora, two at Joliet and two at La Grange. The governor used is of the flyball type, regulating the speed, according to the demand for gas, up to the maximum speed of 130 revolutions; but should a gas main break the engine could not race, as the governor would shut it down when this maximum speed was exceeded. The governor pulley has a safety-stop attachment by which the machine would be stopped in case the governor belt should break. No figures of value as to the cost of pumping are available, as the conditions are not favorable to economical working. There are four separate stations, and the compressors are not economical in steam consumption. With one large and economical plant, it is estimated that gas can be pumped at 60 to 75 lbs. pressure at a cost of 2 cts. per 1,000 cu. ft., including the maintenance of the station.

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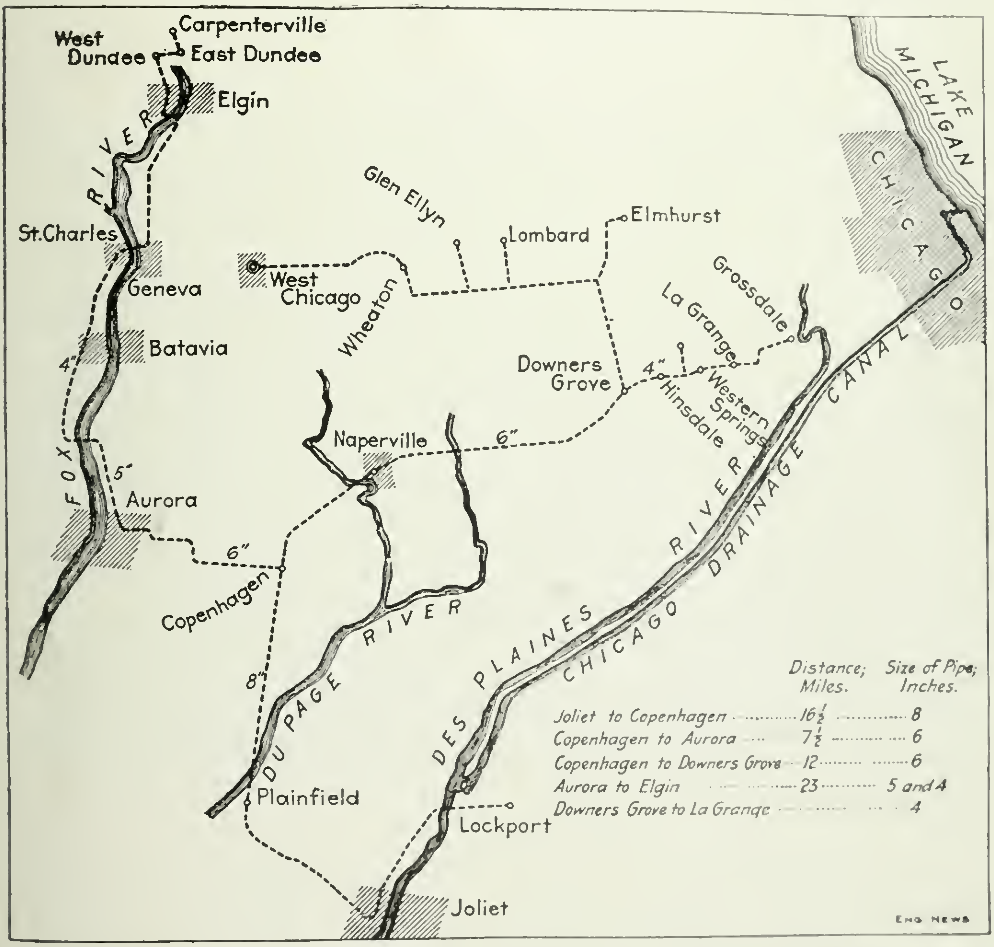
*Engineering News.



	Distance; Miles.	Size of Pipe; Inches.
Joliet to Copenhagen	16½	8
Copenhagen to Aurora	7½	6
Copenhagen to Downers Grove	12	6
Aurora to Elgin	23	5 and 4
Downers Grove to La Grange		4

SKETCH MAP OF GAS DISTRIBUTION SYSTEM OF THE WESTERN UNITED GAS AND ELECTRIC CO.

Tests of the power required to pump 10,000 cu. ft. per hour of gas at 63° F. against gage pressure of 10 to 42 lbs. per sq. in. gave a flat curve ranging from 7½ HP. at 10 lbs. pressure to 13 HP. at 22 lbs., 18½ HP. at 32½ lbs., and 23⅓ HP. at 42 lbs. Tests of the flow of gas on the line from Aurora to Elgin, equivalent to 21½ miles of 4-in. pipe, and tests of the flow of gas through 1,048 ft. of 1-in. steel pipe, are given below. In the former case all consumers were shut off the line as far as St. Charles, at which point the pressure was taken, the pressure at Elgin (as shown by the rise at the gasholder) being about 2 to 3 ins. of mercury. In the latter case the pipe was laid around the Aurora gas works with such long curves that they could practically be ignored.

In regard to the effect of compression upon the quality of coal gas and water gas, Mr. Rice states that there is already a tendency towards higher pressures than those now employed, and that there is immediate need of

TESTS OF FLOW OF GAS IN PIPES

21 miles of 4-in. pipe				1,048 feet of 1-in. pipe		
Gage pressure		Delivery per hour		Gage pressure	Flow per hour	
Aurora lbs.	St. Charles lbs.	Actual cu. ft.	Theoretical cu. ft.	lbs.	Actual cu. ft.	Theoretical cu ft.
15	7½	8,400	8,528	1 20	550	618
20	9½	9,300	10,374	4.51	1,350	1,402
35	...	16,170	15,645	10.64	2,390	2,381
50	30	22,860	20,743	17.00	3,550	3,258
				25.00	4,580	4,295
				35.00	6,000	5,520
				40.00	6,977	6,141

definite knowledge as to the effect of this higher compression on the candle-power and especially as to the heat-units, as direct candle-power is becoming of less importance to the consumers.

Working with two or more stages in compression instead of one, common practice in other pressure work, six times the pressure can be secured with about twice the horsepower. Six times the pressure means five times the delivery. With economical engines and compressors the steam cost of the additional horse-power will be still further reduced in comparison with present installations. These are the every-day facts of the natural gas engineer, who pumps his product at greatest economy at about 300 lbs. pressure.

It is proposed to economize in the cost of producing gas by concentrating the manufacture in one large plant at Joliet, and pumping with an initial pressure of 50 lbs. per sq. in. This would involve the re-pumping at Aurora of gas for Elgin, if the present route is maintained; but a new and more direct route is proposed on which this would not be necessary. The water gas plants at Aurora and Elgin would be maintained for an auxiliary supply in case of necessity. The present gasholder stations would also be maintained, and perhaps be supplemented by others, but nothing has yet been determined as to this feature of the work.

In addition to its gas plants, the company operates a modern electric generating station at Aurora, supplying electric light and power within the city. It does not light the streets, however, as this is done by the municipal electric light plant.

OXONE

The Niagara Electro-Chemical Company of Niagara Falls, has a new product, to which the name "Oxone" has been given. It is a discovery of George F. Brindley, who for years has been manager of the Niagara plant, but who will shortly depart for the Orient. It is a specially prepared fused form of sodium peroxide, bluish gray in color, and has the peculiar property of emitting free oxygen when it comes in contact with carbon dioxide charged with moisture. It is this peculiar quality that arouses the belief that "Oxone" is to be particularly beneficial in submarine navigation, for the use of "Oxone" aboard the submarine vessels will insure a supply of pure air, for it will keep the supply of free oxygen quite constant.

Two experiments made with "Oxone" in Niagara Falls have attracted attention. The first was the placing of a man, Dr. R. von Foregger, in an air-tight box, three by six feet in size, two pounds of "Oxone" being placed in the box with him. According to calculations made, the air supply in the box should have lasted Dr. von Foregger about 20 minutes, after which he should have succumbed to asphyxiation. Instead, however, he remained in the box six hours, smoking and reading. He suffered no distress, but apparently was exhilarated. At the end of six hours the air in the box grew bad very rapidly, but the conclusion was that had more "Oxone" been used he could have remained in the box for a longer period of time.

Still another experiment was made before the Western New York section of the American Chemical Society in the public library building in Niagara Falls on the evening of Tuesday, April 3d, when five healthy rabbits were placed in an air-tight box with something over six ounces of "Oxone." At the end of three hours they were taken out, in seemingly perfect condition.

A further use for "Oxone" may be found in its probable usefulness in connection with mining. "Oxone" generators in the form of a portable apparatus may be placed on the market. In this form the new product would be of value to country physicians who might be called upon to provide a supply of free oxygen in cases of serious illness—pneumonia, for instance.

AIR LOCOMOTIVES IN THE SOUTH

A novel use of compressed air is made by some railway companies in the Southern States of America, says the Railway News. When the loads of cotton for export are being taken to the coast there is always some danger of such highly inflammable material becoming damaged through sparks from the locomotives. To prevent this the locomotive boilers are filled with compressed air. A train load of several thousand bales of cotton can be hauled by these locomotives at a rate of 12 miles an hour, although no fire whatever is used in working them.

EDUCATION OF APPRENTICES AT THE TARRYTOWN SHOPS OF THE RAND DRILL COMPANY.

Written for Compressed Air by an Apprentice.

For several years previous to the consolidation of the Rand and Ingersoll-Sergeant Companies there was maintained at the Tarrytown shops of the former company a most unique system for training prospective salesmen. Unlike other large manufacturing concerns, the Rand Drill Company did not believe in setting the young engineers who applied for positions in their company to work in the shops, but pursued a course of systematic training in theory as well as in practice. The president of one of the largest machinery houses in the United States once said to the writer, after hearing about the Rand training system, that his experience had always been that the best salesmen came in through the office and never through the shops. This sums up in a few words the policy of the Rand Drill Company; their salesmen came in through the *office* and the only shop work done by them was what they wished to do of their own free will. In fact they were left to work out their own education in their own way and were not placed under the orders of shop foremen or in any way made to feel that manual labor was expected of them. On the other hand, however, they were expected to work, and to work hard. To this end a list of over 300 questions was handed to each applicant on his arrival and to answer all of these correctly meant that many a night was spent in hard study and in writing out information acquired during the day. These questions not only covered the entire field of compressed air, but dealt with the best practice in power plant design, installation and equipment of central compressed air power plants and many practical questions on steam engineering.

A CLASS OF APPRENTICES AT THE TARRYTOWN SHOPS OF THE RAND DRILL CO.

It was presumed that most applicants for positions would be graduates of technical schools and colleges, but as none of the colleges at present devote much time to the subject of compressed air, it was necessary for these men to study the subject from the beginning and it could do no harm for them, at the same time, to brush up on the subjects of boilers and steam engines. There were also men in the class who had no college education and a number of elementary questions were placed on the list for their benefit. As a rule the various classes were made up in a most impartial manner, no favoritism being shown in appointments, but applicants were most carefully selected. The class of 1904 contained men from various sections of the country. The college men consisted of two men from Columbia University, one from University of Vermont, one from the Massachusetts Institute of Technology, and one from New York University. Besides these there were two men who were not graduates of technical schools, one being from Chicago, and the other from Mt. Vernon, N. Y.

As soon as the men had had time to acquire some information on the questions submitted, a course of lectures and recitations was inaugurated under the auspices of the Chief Engineer, to whom, alone, the men were held responsible. Every Wednesday evening the drafting room was turned into a lecture hall and discussions were held upon a certain number of questions. Much information was given to the men at these lectures which they could not acquire in the shops.

While the greatest emphasis was necessarily laid upon those questions which dealt primarily with the advantages and disadvantages of Rand machinery, a great deal of time was devoted to a study of the output of competing firms and to this end a room, set apart for the apprentices, was fitted up with rock drills of all the principal makes, some of them being of foreign manufacture, and every facility was afforded for taking these machines apart that a study might be made of their merits and demerits

In order to become familiar with the assembling of the various types of air compressors and rock drills, a few weeks were spent on the erecting floor and in the drill room. Considerable time was also spent in the stock room for the purpose of becoming familiar with the various machine parts.

As time went on special lectures were delivered upon selected subjects. The Air Lift System of pumping was treated by the Chief Draftsman, and lectures were delivered upon practical subjects by others in the employ of the company.

Exhaustive tests on compressed air appliances were carried out by the men, and pneumatic plug drillers, chipping hammers and riveters were tested for their air consumption, driving force, efficiency and durability.

A more comprehensive course in the applications of compressed air it would be hard to find, and the writer feels that he has received an education in this subject which can only be obtained by other men after many years of experience.

In comparison with the methods in vogue at other manufacturing plants, the Rand system has many points of superiority. The training in theory is a great advantage and the universal courtesy extended to the applicant instills in his mind a high regard for his employers and develops an esprit-de-crops that it would be hard to duplicate.

GROUTING BY COMPRESSED AIR.

In the January number of Compressed Air, (Vol. 10, No. 11, page 3871), appeared a short item from the Railway News of England regarding the use of grout for repairing the Winchester Cathedral which was in danger of collapsing, a grouting machine invented by the late Mr. Greathead for tunnel purposes, being used in connection with the work. A number of inquiries have been received by Compressed Air regarding this machine, and through the courtesy of the makers, Messrs. S. Owens & Co., of Whitefriars, London, E. C., England, we are enabled to present to our readers the following detailed description.

The device is the result of much thought and experience, the nature of the work requiring the use of a machine as simple as possible in construction as any complication of parts would be fatal to its extended use. It was the aim of the manufacturers, therefore, to design a machine which would represent efficiency and simplicity. How well they have succeeded is shown by the accompanying drawings.

As will be seen, the apparatus consists of two cylindrical galvanized tubes of air tight construction, in the larger of which is fitted a pair of specially constructed air pumps situated inside the air receiver with delivery valves opening therein—air suction valves being lodged in the several buckets. Motion is given to the buckets by means of connecting rods and the usual crank and fly wheel. The compressor is fitted with a relief valve and pressure gage and a special air screw-down valve from which runs a flexible air pipe to the second smaller cylinder, termed the grout pan. This is fitted with a wrench cover and opens for the reception of mixed Portland cement or grout. The inside of this cylinder is fitted with a series of beaters on a central spindle which, during the process of grouting, are kept revolving in order that the slurry may not have time to settle. A controlling valve or cock is fitted to the grout delivery outlet from which a length of hose, fitted with a cone chamber outlet, delivers the grout at the required point of application.

The method of operation is as follows: The mixture of slurry or grout is prepared while the air pressure is being raised. When the grout becomes sufficiently fluid it is poured into the grout pan, the lid of which is immediately closed and the beater set to work. By this time the air pressure in the receiver has attained its maximum and is allowed to pass into the pan by opening the regulating valve. The operator at the nozzle in charge of feeding the grout then allows the contents of the pan to be ejected to the required spot. The mixing of cement again takes place and the process is repeated until the entire work is carried to completion.

It will be seen that by this means it is possible to inject fluid cement into places which would be inaccessible by any other method. The process is adapted for use on foundations, sea walls, repairing buildings, etc.

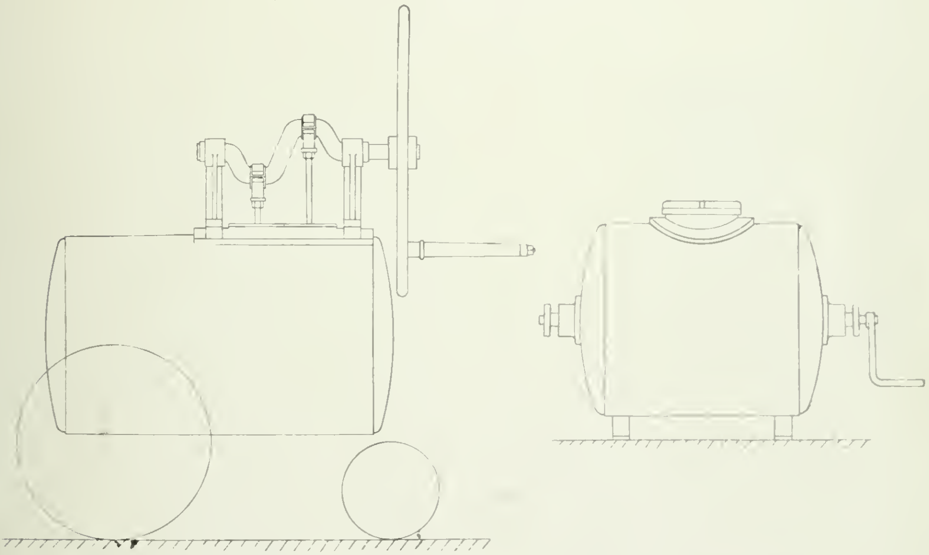
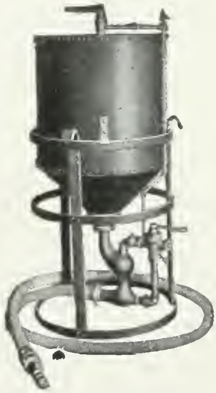


DIAGRAM OF GROUTING MACHINE MADE BY S. OWENS & CO., ENGLAND.

THE SAND BLAST.

Written for Compressed Air by
J. M. Betton.

In a sand blast apparatus, and especially in the Injector Sand Blast, the injector principle is followed closely in first starting the flow of sand by creating a mild vacuum, by means of a vertical jet through the sand valve, equivalent to the suction jet of the steam injector, mixing the sand and air by means of the second vertical or mixing jet which also starts the combined current forward, and by augmenting the velocity of the current, using a horizontal or forcer jet, as well as by contracting the walls of the mixing chamber. In other words, the air supply is subdivided and applied at such points and in such a manner that its effort is cumulative, producing a very vigorous blast of sand and air, so thoroughly mixed that each grain of sand may be considered as being projected upon the work individually and with the greatest obtainable velocity, the thoroughness of cleaning by means of the sand blast depending upon the force of the impact of the individual grains of sand. It is the sand only that does the work; the air jet alone would only blow off the loose surface. By so subdividing the air, the same results are attained with the Injector Sand Blast, with less consumption of air, than with the ordinary sand blast, in which the sand drops from the sand tank into a current of air and is blown on to the work by sheer brute force.



EXTERIOR OF INJECTOR SAND BLAST.

Successful operation of the sand blast is insured by providing an ample volume of air. The table on page 4115 gives the number of cubic feet of free air per minute required under different pressures and with various sizes of nozzles, and in general practice the amount of free air so stated should be provided, using for this purpose an air compressor, of any type or make, of ample dimensions to deliver the desired quantity at a moderate speed; 150 revolutions per minute is customary.

From the compressor the air should be led into an air receiver, either vertical or horizontal, taking care not to reduce the size of the air delivery pipe. This receiver for ordinary foundry work may be 30" diameter and 72" in height, and should be provided with a safety valve, pressure gauge and blow-off cock, the latter near the bottom, to remove any water condensed from the air.

It is especially desirable that the air piping from this receiver to the sand blast be not less in diameter than the air connection of the sand blast. If the distance between the receiver and the sand blast is more than 75 feet, the pipe should be larger than the air connection of the sand blast, to allow for loss for pressure from friction. It is not that the sand blast will take all of this air: it can only take the amount which the nozzle will discharge under the working pressure; a ½" nozzle under 30 lbs. pressure will take 161 cubic feet of free air; but the best and satisfactory results are only obtained by having this backing of air behind the jets.

If the air system is already established and the pressure carried is 80 to 110 lbs. necessary for the successful operation of pneumatic tools, the pressure may be reduced by means of a pressure-reducing valve, or a separate air compressor installed for the sand blast only.

If a reducing valve be used, the air should be led from it into a supplementary air receiver, from which it is piped off to the sand blast.

This supplementary receiver need not be large; a galvanized kitchen range boiler 12" in diameter and upwards or a section of large pipe can be used, a pressure gauge being conveniently attached.

The sand tanks of the Injector Sand Blast are marked "Good for 40 lbs. pressure" as a matter of precaution. They are tested under 80 lbs. air pressure, and while they can be used under higher pressures 40 lbs. is as high as any ordinary sand blast work requires, except for steel castings.

The air piping should be protected from condensation if the lines be long, and if moisture or water shows in the air at its entrance into the sand blast, it is necessary that some means of removing this and drying the air be provided. This can be done by an "After Cooler," or by means of one or more "U" loops introduced in the line of air piping. Drip cocks at the bottom of these loops will draw off the entrained water, or it may be removed by an ordinary bucket steam trap.

Water must be kept from the sand to insure proper working of the sand blast. If it enters the tank it will cause the sand to cake and arch over the sand valve, and the only remedy is to shut down, draw off the sand through the drain hole in the bottom of the sand tank, and start over again with dry sand.

Dry sand if left in the sand tank over night will absorb moisture and may refuse to flow the next day, and for this reason it is recommended that the sand tank be always emptied at the close of the day's work. A very little experience will enable the operator to gauge the filling of the tank to the day's work.

The sand should be perfectly sharp, clean quartz or silica, sifted through a screen of proper mesh, and dried long enough beforehand to have it cold when used. If too warm, it will create steam within the tank. If heated too hot, it will crack and disintegrate.

The sand can be dried in any manner most convenient, on a steam table, or in a dryer made by building a flaring hopper around a small coal stove, the dry sand falling to the ground through suitable openings in the bottom of the hopper.

Almost any sand can be used, but it will be found that sands containing an undue amount of clay or mould will give this off in the form of dust, causing discomfort and doing no part in the actual cleaning. An examination of sand under a pocket magnifying glass will be found valuable in determining whether to use a sand or not.

With a ¼" nozzle, always screen the sand through a No. 8 mesh screen, which will remove all pebbles, sticks, etc., too large to pass through the nozzle, as a small obstacle will stop this at times. Should this occur shut off the sand blast by closing the sand valve, then shut off the air and open the air cock at the top of the tank. When the pressure falls, the nozzle can be quickly removed, cleaned out and replaced.

If this is done when the pressure is on, the operator should be careful of his eyes when the nozzle tip is removed, as the sand will fly under the air pressure behind it.

With ½" nozzles a very much coarser sand can be used, and the Injector Sand Blast has been operated successfully with pebbles averaging ⅛" in diameter, using them again and again. These quickly rounded off their sharp edges, and their action upon the castings can be compared to that of peening them with an infinite number of small ball-peen hammers, cleaning them very thoroughly and giving a very good finish. A coarse sand or gravel will be found effective for general work in the foundry and especially for steel castings.

Any expensive or intricate device for removing the dust during the work of sand blasting or for saving and removing the sand will generally be found inadvisable. Numbers of these have been installed, but have seldom been duplicated, and in every case they have been sources of constant care, repairs and expense. It is advisable to clean castings as near out of doors as possible, in an open shed or in a room with a large door or windows open to the air. Let it have a tight floor, covered with sheet iron; have benches for holding the castings, with bottoms made of wire screens, and let the sand fall through to the floor, removing it by hand from time to time, screening it and using it again. Foundry labor is not expensive. If the dust is excessive, remove it by an ordinary exhaust fan.

Diameter of Nozzle in inches	AIR GAUGE PRESSURES IN POUNDS					
	5	10	15	20	25	30
¼	15.4	21.8	26.7	30.8	34.5	40.
⅜	34.6	49.	60.	69.	77.	90.
½	61.6	87.	107.	123.	138.	161.
⅝	96.5	136.	167.	193	216.	252.
¾	133.	196.	240.	277.	310.	362.
⅞	189.	267.	326.	378.	422.	493.

AIR PRESSURE REQUIRED.

For Light Work (stove castings, etc.)	5-10 lbs.
For Medium and Heavy Grade Iron Castings,	15-20 lbs.
For Steel Castings,	30-75 lbs.
For Cleaning Buildings and Steel Structures, (According to Height.)	5-30 lbs.

Care should be taken not to locate the sand blast near the air compressor, especially if the latter is also used to supply pneumatic tools, for the dust will not only cut the air cylinders, but will prove very troublesome in those of the tools and in the valves, and may necessitate their renewal.

The operators should preferably wear regular sand blasters' helmets, which have loose hoods descending over the shoulders, arranged to tie at the bottom.

If the work is continuous it is well to use a respirator or muzzle to cover the mouth and nose, and prevent the inhaling of too much dust. A wet sponge will answer fairly well for this purpose. When the work is done out of doors or with free access to the air, the discomfort from dust is not very great, increasing, of course, if the operator is working in a confined space. Rubber or leather gloves are desirable to protect the hands from the sand.

The helmet is not necessary and many operators use only goggles or large stone cutters' spectacles of plain glass, and cover their noses and mouths with cloths or sponges.

Any playing with the sand blast when in operation should be emphatically discouraged. The sand will fly farther than might be expected, and the chances of injuring some bystander's eyes are too great to take any chances on.

Of the various sizes of sand blasts now on the market, the 24" x 24" is best adapted to general work in cleaning small castings, and especially for cleaning the brick and stone work of buildings. The 30" sizes are identical in operation, differing only in capacity; the 30" x 36" (capacity 1,200 lbs. sand) when operated under 25 to 30 lbs. air pressure and with a ½" nozzle, will require filling about twice in a day of 10 hours, and the 30" x 48" (capacity 2,000 lbs. sand) will require one filling in the same time.

In considering the quantity of air required per minute to operate the sand blast, the quantity of sand therein may be disregarded. It will not exceed 1 per cent. volume to volume of the air.

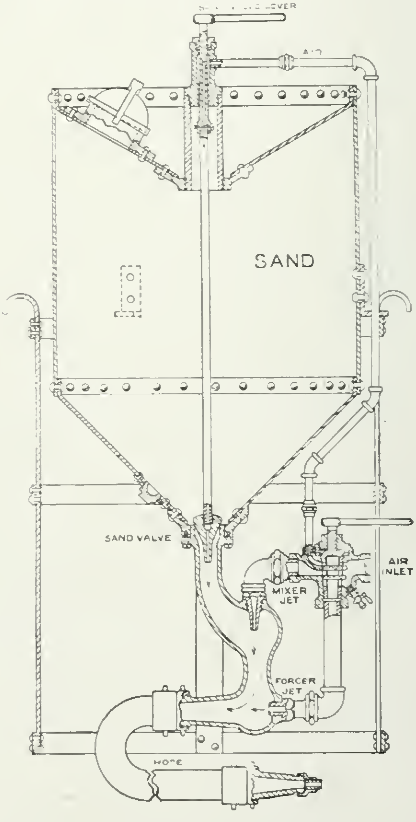
For cleaning the exteriors of buildings, structural steel work, as bridges, etc., there will be required a portable air outfit, mounted on wheels, comprising an air compressor of compact form (about 12" x 8") operated by a gasoline or petroleum engine, belted or geared to the compressor; the engine should be about 12 H. P. There should be a gasoline tank hung under the body of the truck and also a water tank or cooler for the jacket cooling water, although this can usually be obtained through a line of hose from some faucet or hydrant in the building being cleaned. There should also be provided an ample air receiver. The truck should be covered with a permanent top or by canvas curtains—the closer the better, as any brasses, as lubricators, etc., are liable to be stolen.

This outfit will keep two 24" sand blasts at work, these being located on the ground at the side of the building being cleaned and connected to the air receiver by lines of ¾" rubber hose.

The mixed air and sand is carried up to the highest points of the building through a line of ¾" rubber hose, the end of which is provided with a "Y" fitting enabling two nozzles to be led from the main delivery hose and two operators to work from each sand blast.

The sand should be fine, sharp and perfectly dry, and the air must be dry also; and this work cannot be done when the weather is unfavorable, rainy, or damp and foggy.

The operators work on light swinging stages about 20 feet in length, similar to those used by painters, and these are usually enclosed by a close canvas screen extending along the rear and two ends, and also below the staging where it is made in the form of a hopper, terminating in a canvas chute about 6" in diameter, through which a large proportion of the sand falls to the ground and is used again. The operators usually protect their faces by helmets.



SECTIONAL VIEW OF INJECTOR SAND BLAST.

An air pressure of 30 lbs. is usually enough to carry the sand to the cornices of the highest buildings and to do effective work. In operating on marble and sandstone care must be taken to regulate the air pressure and not to have it too high. The carving on such material absorbs moisture and becomes soft and disintegrated, and if the sand blast is too vigorous, many small details of the design can be speedily obliterated beyond replacing.

In cleaning steel work of bridges, viaducts, etc., a moderately high pressure will be found very effective and will clean the steel down to the original gray metal.

By adapting the air pressure, grade and quantity of sand to the work to be done, satisfactory results can be readily obtained with the sand blast, and its field of usefulness greatly enlarged.

LIQUID AIR IN MEDICINE AND SURGERY.

Valuable experiments have been made in the therapeutic value of liquid air. In an account of the work with this medium a specialist says: —"Any inflammatory process where cold applications in any form are a desirable part of the treatment can be administered more satisfactorily with some form of liquid air in application than in any other way. For example, an inflamed knee or other joint can be exposed to the dry, cold vapor emanating from a vessel of boiling liquid air, and any degree of temperature can be given, and the temperature of the joint or part can be reduced to any desirable point. Another method, quicker in its after effects, is to soak a towel in the liquid and apply it quickly and intermittently till the part has been thoroughly chilled. A glass bulb filled with the liquid and rolled over the surface of the joint is another efficient means of accomplishing the result. A current of air can be sent through the ice coil, providing there is protection between the coil and the skin, to great advantage when cold is a desirable adjunct, as in the case of acute abdominal troubles, such as appendicitis.

"To produce an inflammation or stimulating effect the liquid air must be applied directly and intermittently to the skin. The best example of this effect is seen in chronic indolent ulcerating surfaces, when by spraying here and there over the surfaces just sufficiently to freeze for a second only a good, healthy, granulating surface will be obtained after only a few treatments of this character.

"It can be readily understood that any foreign growth upon the skin or within reach of operation can be destroyed by liquid air. It may take two, three or more applications. The only danger to be avoided is excessive freezing, which results in inflammation. The air inflammation subsides quickly and responds readily to hot boracic acid or carbolic fomentations. If such a growth as a naevus or any birthmark or tumor be treated judiciously it can be removed much more quickly and with less pain than by any other method. If not done too rapidly no scar is left to show its location.

"In the treatment of carbuncles not too far advanced, not more than three inches in circumference, liquid air seems to act as a specific. In all cases treated under this size activity has been aborted within an hour after freezing. If liquid air could be of service only in the treatment of the carbuncle its success in this one lesion would be sufficient reward for its discovery."

A MEANS of continuously measuring the work performed in the steam cylinder of an engine is now afforded by an instrument, consisting of an ordinary steam indicator, in which the pencil is replaced by a planimeter wheel, the only difference being that instead of the spring-loaded piston causing a pencil to be raised and lowered proportionally to the pressure, the planimeter wheel is canted proportionately to it. The effect of this, when the wheel is made to bear continuously on the drum, which ordinarily carries the paper, is to make it rotate proportionately to the area which would have been described by the pencil. This rotation is recorded by suitable mechanism, and it is only necessary to know the length of the imaginary card, and to apply the necessary constants to the reading, to know the total horse-power recorded

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, Mem. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., . Managing Editor
P. F. KOBBÉ, JR., . . Business Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. JULY, 1906. No. 5.

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MOISTURE IN AIR.

In considering questions of moisture and temperature in air the physical reactions are the same whether the air is free atmospheric air or confined compressed air. In other words, the conditions that exist in the atmosphere generally, producing and dissipating moisture, the effect of heat and cold on air, as exhibited by weather conditions generally, may be, and are, produced in compressed air under similar conditions. The production of fog, for instance, is the condensation of the moisture in the air due to cooling. As the air becomes cooler it shrinks and the moisture is precipitated. In an air lock it is common practice to note that while unlocking; that is, coming through the lock, and as the pressure is being reduced by opening the discharge valve, a fog accumulates, becoming thicker as the temperatures and pressure are lowered. The writer at one time was attacked by the "bends," or the caisson disease, after coming out of the old Hudson River tunnel. He was promptly taken into the "hospital", which was nothing but a horizontal tank about the size of a common locomotive boiler. The pressure, amounting at that time to some 30 pounds, was admitted, and it acted instantly to relieve pain and to produce normal conditions. He was told to open the throttle valve and let the pressure out so that he might open the door. As he did this he noticed that the temperature was gradually lowered and at a certain point, known as the dew point, he was enveloped in fog. The pain returned about this time so that he shut off the discharge valve and opened the cock, admitting compressed air. The fog immediately disappeared, the temperature was slightly increased and the pain stopped. This condition was repeated several times, so that here is a means by which "artificial" fog may be produced at will.

The same physical laws apply in the production of fog as in the condensation of moisture on the exterior of an ice pitcher or on a window pane in winter time. In one case, that of the fog, the moisture is in suspense; that is, it is aerated, because the thing which cools it and upon which it attaches itself is air, while in the case of the ice pitcher and window pane there is a solid substance upon which the moisture adheres, congealing from fine foggy particles to a condition of water. In each case the initial step which produces condensation is a lowering of temperature. The capacity of air to hold moisture is a question of temperature, not of volume. We have a certain quantity of air and it contains a certain quantity of moisture. If that air is rapidly reduced in temperature moisture will accumulate because the air is unable at the reduced temperature to hold the moisture that is present.

The physical conditions referred to are found during the compression and use of air. There is a system known as the Taylor system for compressing air hydraulically. This Taylor system has been described as the Pohlé pump reversed. The Pohlé pump lifts water from wells by inserting compressed air at the bottom of an eduction pipe. The column from the bottom of the well to the surface is a mixture of water and air. The Taylor hydraulic system of compression is a Pohle pump turned upside down. Water is carried down through a pipe into a well or over a dam and in going down it carries air with it. The deeper it goes the more is this air compressed, but from the top to the bottom there is a constant contact between the air and the water. Now it is a singular fact that the Taylor system of pumping produces dry air. Compression of air under the usual conditions results in the accumulation of moisture either in the air receiver, the pipe line or in the motor. Moisture in compressed air is a serious matter and many difficulties arise from its presence. One would naturally suppose that the Taylor system, or any system of compressing air by water, would result in moist air. The contrary is the fact, and the reason for it is plain. In the first place the water is cold, hence the air is reduced in temperature. This reduction causes condensation of moisture on the water surface of the bubble of air, hence the water is constantly taking water out of the air. Water has an affinity for its like and is an excellent condensing medium. Again, when the air is produced by this hydraulic system it is discharged at reasonably low temperatures —temperatures usually lower than those at which it is used, hence from the time of compression to the time of use there is an increase in temperature which means a drying process or a lessened liability to drop moisture.

Another illustration of this point is shown in the water injection air compressor, which forces a spray of water into the cylinder during compression. So long as this water is cold the air is produced comparatively dry. When the Washington (D. C.), aqueduct was built—about twenty years ago—water injection air compressors were used. Difficulties were experienced in keeping sufficient cold water in contact with the air during compression, hence the discharge pipes accumulated considerable water due to reduced temperatures as the air was carried over the hills, aided perhaps by insufficient areas of valves and passages, which resulted in carrying some of the injection water over with the air. However this may be, the remedy was found by pumping cold water into the air receivers and discharging the compressed air directly from the compressor below the surface of the water in the air receivers. So long as the water in the receivers was kept cold this air when discharged below the surface left its moisture in the receiver and no further trouble was experienced in the line or in the tunnel.

The points mentioned are pertinent just now in connection with efforts made by the Rapid Transit Commission in New York to make the Subway more comfortable. The popular impression that the Subway is badly ventilated is erroneous. It is a rare thing that tunnels are as well ventilated as the New York Subway. The shafts are usually four in number, situated about half a mile apart, and anyone going up or down the stairs realizes the thorough draft of air in and out, which cannot but produce wholesome ventilation. The trouble with the Subway is that it is hot and that the conditions of moisture are uncomfortable. Dr. George A. Soper was employed by the Rapid Transit Commission to investigate the air in the Subway. He reported that in July last the Subway was 5.6 degrees warmer than the street; that in the fall of the year the warmth of the Subway was greater relatively than on the street, the difference at one time being as great as 15 degrees. As to humidity, Dr. Soper said that it had been found that the Subway was dryer than the street. Dr. Soper referred also to the dust in the Subway as being composed largely of bits of iron which came from the wear of the brakes.

The chief trouble is one of temperature, and although every one does not agree with Dr. Soper in that the air in the Subway is dryer than the air in the street, yet the uncomfortable *feeling* which undoubtedly exists there is due mainly to the temperature conditions. The simplest way to remedy this is, of course, to "lift the lid," but as this cannot be done it becomes a question of how best and cheapest to cool the Subway. It is plain that a system of cooling pipes, carrying brine, might be established throughout the limits of the tunnel, and in this way the temperature might be considerably reduced, but the expense of such a system would be great, and while the temperature conditions would be improved the uncomfortable effect from the dust particles would still exist.

What simpler or better plan can be found than to use natural conditions of moisture and air? We have all noticed that on a muggy day the atmosphere has a regular Subway feeling and that along during the afternoon as the clouds accumulate and rain falls in torrents this muggy atmosphere is cleared and it has a crisp, fresh feeling. This is due to cooling and condensation of moisture. In the Subway, between the stations and directly over the tops of the cars, pipes might be laid, discharging a spray of air and water, the compressed air being used at moderate pressures simply to spray the water, and in this way a certain reduction in temperature would result and a clearing of the atmosphere by a washing process. This need not be carried out to the extent of producing any large volume of water. On the contrary, the spraying of the water acting like a garden hose would produce the maximum cooling effect with the minimum quantity of water used. There must surely be in the Subway sufficient provision for drainage to take care of what little water might be discharged on the floor. Furthermore, it would seem that if the drainage conditions there are not sufficient they should be increased, because it would certainly do the Subway no harm to be washed in this way. One objection to the Subway is that there is an accumulation of dirt in the roadbed which gets no chance to be clarified. The spray system of cooling by compressed air and water is not a new thing. It is found in natural as well as artificial conditions. Mines that are very wet, as for instance the Clover Leaf in the Black Hills, where water pours in streams through the roof, is one of the most comfortable mines to work in, because there is a crisp, cool feeling to the air and a freedom from all muggy Subway conditions. The spray system has an additional cooling advantage in that the conversion of the particles of water into vapor absorbs heat, just as heat is absorbed when water is converted into steam. These particles of vapor must get their heat from the atmosphere as the steam gets its heat from the coal and water.

IS IT MR. ANANIAS OR MR. IGNORANCE?

Is it Mr. Ananias or Mr. Ignorance who writes machinery catalogs, or do they collaborate? The thought prompting the question that forms the title of this editorial is induced by the sights one sees on every side of small machinery installations which come to grief on the rocks of misrepresentation.

Who misrepresented?—Mr. Ananias or Mr. Ignorance? Let us consider misrepresentation by catalog and leave to some future time the discussion of the same trait in the salesman.

The aim of the machinery catalog should be to show the prospective user that it is to his interest to *buy*, to bring to his attention the merits and advantages of using the particular machine referred to in the catalog and to keep within known facts in order that the buyer of small installations may gage his requirements in cases where several machines are dependent on each other for the efficient and economical operation of the entire plant.

We will give an imaginary case that could easily hold true and no doubt does hold true in many instances.

Mr. Stoneman owns and has been operating for some years a quarry out of which he has been able to make a scant living besides laying up a little capital. He hoped to install up-to-date tools in order to get what he considered his rightful share of this world's goods. He knew his output was costing him too much and his limited capital would not allow him to call into consultation an experienced engineer; but a happy and brilliant thought struck him—he would send for catalogues! In his innocence he decided to read up the catalogues and "figure out his own plant."

Mr. Compressorman says in his catalogue that he has a machine with a capacity of 100 cu. ft. of free air per minute when running at "N" revolutions per minute and states somewhere in the catalogue, inconspicuously so that it will not prove offensive to the eye, that this is "piston displacement." He seldom if ever mentions that his compressor has a volumetric efficiency of, say, 80%, and that his machine only delivers 80 cu. ft. of free air. Mr. Stoneman "figures" on 100. He sees by Mr. Pneumatic Toolman's catalogue that this will run five plug drills continuously—for doesn't the catalogue say that each one takes 20 cu. ft. of free air per minute at "N" pressure? Then Mr. Rock Drillman tells him that his make of tools will drill 70 ft. in 10 hours and will use "N" pounds of steam. Mr. Boilerman can supply just the right boiler to run these drills—his catalogue says so. Mr. Stoneman decides to run his 10 H. P. (catalogue rating) compressor with Mr. Gas Engineman's 10 H. P. (catalogue rating) gas engine.

MAY SUCCESS CROWN HIS EFFORTS.

Mr. Crusher's machine will take care of 200 tons of rock (catalogue rating) per hour and requires "N" H. P. Mr. Steam Engineman describes in his catalogue just the engine for this work. And so on *ad infinitum!*

Mr. Stoneman "figured out his own plant," but shortly after he had put his capital into catalogue-rated machinery he had an awakening, the shock of which need not be dwelt upon.

And why should this condition exist? Why are the present day catalogues of use chiefly as samples of high-grade printing—because the "other fellow" rates his machinery way above its possible capacity? *Does the salesman follow up the catalogue verbatim*, or does he modify the cold hard type and let himself and his employer down as easily as possible by obscuring the inconsistencies with a voluminous discourse couched in hyper-technical terms?

DENATURED ALCOHOL.

Now that the free alcohol bill has been passed by the Senate we believe that our readers may be interested in knowing how this alcohol is prepared for market, and Germany, being the largest manufacturer of this substance, is naturally looked to for the required information.

This matter has been very ably treated by Mr. Mason, formerly Consul General to Berlin, in some of his reports. He states that most of the free alcohol used in Germany is "denatured" or rendered unfit for drinking purposes by admixture, in the presence of a government official, of a number of different substances prescribed by a very elaborate statute which governs this complicated subject. There are two classes or degrees of denaturalizing, viz, the "complete" and the "incomplete," according to the purposes for which the alcohol is to be ultimately used.

Complete denaturalization of alcohol by the German system is accomplished by the addition to every 100 litres (26½ gals.) of spirits of: (a) two and one-half litres of the "standard denaturalizer," made of four parts of wood alcohol, one part of pyridin (a nitrogenous base obtained by distilling bone oil or coal tar), with the addition of 50 grams to each litre of oil of lavender or rosemary; (b) one and one-fourth litres of the above standard and two litres of benzol with every 100 litres of alcohol.

Incomplete denaturization, i. e., sufficient to prevent alcohol from being drunk, but not to disqualify it from use for various special purposes, for which the wholly denaturized spirits would be unavailable, is accomplished by several methods, as follows, the quantity and nature of each substance given being the prescribed dose for each 100 litres (26½ gals.) of spirits: (c) five litres of wood alcohol or one-half litre of pyridin; (d) 20 litres of solution of shellac, containing 1 part gum to 2 parts alcohol of 90 per cent. purity (alcohol for the manufacture of celluloid and pegamoid is denaturized); (e) by the addition of 1 kilogram camphor or 2 litres oil of turpentine, or one-half litre benzol to each 100 litres of spirits

The price of denaturized alcohol varies in the different States and provinces of the German Empire in accordance with the yield and consequent market price of potatoes, grain and other materials. At the present time alcohol of 95 per cent. purity, which is the quality ordinarily used in Germany for burning, sells at wholesale from 28 to 29 pfennigs (6.67 to 6.9 cents) per litre (1.06 quarts), and at retail for 33 pfennigs (7.85 cents) per litre

Of completely denaturized alcohol there was used in Germany during the year 1903-1904, 931,406 hectolitres denaturized by process (a), as described above, and 52,704 hectolitres which had been denaturized by process (b) This made a total of 26,080,505 gallons of wholly denaturized spirits used during the year for heating, lighting, various processes of manufacture and for the operation of numerous direct combustion engines throughout the empire.

AMERICAN TOOLS ABROAD.

Exports of machinery and tools from the United States have been increasing rapidly. For nine months ending with March the exports of tools of certain classes were a million dollars in value in excess of the exports for the corresponding months a year ago, while saws increased over $100,000, cutlery nearly $150,000, firearms over $500,000, cash registers $300,000, electrical machinery $400,000, metal-working machinery $1,753,000, printing machinery $150,000, pumps and pumping machinery $1,220,000, sewing machines $1,000,000, locomotives $2,300,000, and so on with other articles under the head of machinery.

Lieut. Godfrey L. Carden, writing in *Harper's Weekly*, says:

"Ten years ago one might have traveled the length and breadth of the Rhein provinces, the great iron and steel district of Germany, and in all the leading shops one would have found English tools. To-day all this is changed, and in lieu of English tools one finds now for all ordinary work German stock tools; but one also finds in nearly all the first-class establishments a group of American machine tools for the high-grade work—a silent tribute to the excellence of our output. I found machine tools from Providence, Hartford, Plainfield, Philadelphia, Wilmington, Cincinnati, Hamilton, Cleveland—in fact, from all the first-class American shops. I found no tools of the second or third grade make. If one would know which are the best American machine tools go to Germany. The Germans know."

NEW PUBLICATIONS.

SHAFT GOVERNORS.—By W. TRINKS, M. E., and C. HOUSUM, New York: D. Van Nostrand Co. (Van Nostrand Science Series.) Boards; 3½x6 inches; pp. 97; 27 figures, partly in the text, and 16 tables. 50 cents.

This book is stated to be the outgrowth of notes and rules used by the authors in the design and adjustment of engines. It relates to the statics of shaft governors only, and the authors state that a second volume treating of the subjects; gravity balance, disturbances caused by too small rotating masses in eccentric, synchronous oscillations of spring and various dynamic actions of shaft governors, will shortly be issued if the present volume meets with success. It is very much to be hoped that the volume in hand will receive such a welcome that the authors will feel disposed to present to the mechanical world their further researches in connection with this important subject, as at the present time there is practically nothing published on shaft governors and their design and operation.

The present volume, while highly theoretical in its text, treats the subject of centrifugal moment, reacting moment caused by friction of valves, friction of eccentric strap, spring moment, influence of mass of helical governor springs in a very thorough and exhaustive manner and we believe that on this account this little book should be of the utmost value to designers, manufacturers of steam engines, and engineers in general. In preparing this work the authors have conferred a benefit upon the engineering profession as they have placed before the public exhaustive data upon a subject which hitherto has received very little attention.

MINE AND QUARRY.—Published by The Sullivan Machinery Co. and issued quarterly by their Advertising Department.

The publishers state that the object of this paper is to familiarize each reader with the different classes of machinery manufactured by The Sullivan Machinery Co., and that this aim will be attained by rendering descriptions of engineering, mining and quarrying undertaking of special interest, in which the various machines have been or are employed; by mention and illustration of new machines and of improvements to existing types. They will also render discussions and suggestions regarding the best practice in the application, use and care of machines under different conditions.

The paper is most attractive in outward appearance and its reading matter is exceedingly interesting, containing as it does articles on Rock Excavations at Panama, Modern Methods at an Illinois Mine, Diamond Drilling, The Power Extension of the Chicago Drainage Canal, Low Cost of Compressing Air for Drills, and other items of interest. It is printed on high quality paper and the numerous half-tone illustrations are shown to advantage. *Mine* *and Quarry* will be sent free of charge to any address upon request.

The American Society of Refrigerating Engineers' Year Book for 1906 has just been issued. It contains the constitution, by-laws and directory of members. A copy of this may be had by addressing the secretary, Suite 806, 258 Broadway, New York City.

TRADE PUBLICATIONS.

Pratt Institute, Brooklyn, N. Y. Pratt Institute Record, 1904-1905, containing report of the secretary.

C. Drucklieb, 132 Read street, New York. "Sandcraft," an illustrated booklet covering the design and application of the Injector Sand Blast, and containing much valuable information and data on the general subject of sand blasting.

Westinghouse Electric & Mfg. Co., Pittsburg, Pa. Circular No. 1128, illustrating and describing small power motors.

Purdue University, Lafayette, Ind. Catalogue containing a register of the students during 1905-1906, lists of the faculty and announcements for 1906-1907.

University of Illinois Press Bulletin outlining summer courses for 1906. Contains information relative to the growth of the college and of important fuel tests which will be carried out by the State Engineering Experiment Station recently established at the university.

Milton L. Hughes & Co., Consulting Engineers, 324 Dearborn street, Chicago. A booklet, entitled "The Hughes Idea," dealing with power plant economics and explaining a new and original system for saving money in the power plant.

Stanley Electric Mfg. Co., Pittsfield, Mass. Bulletins Nos. 603, 604 and 605, illustrating carbon-break circuit-breakers and small direct current motors.

Rockwell Engineering Co., 26 Cortlandt street, New York, circular illustrating and describing pot furnaces for lead and cyanide hardening, and for melting soft metals.

Unit Concrete Steel Frame Co., Commonwealth Building, Philadelphia, Pa.—Report of tests on the Unit System of Reinforced Concrete made under the supervision of the engineering staffs of the building bureaus of New York and Philadelphia. Includes tests by loading, fire and water by Prof. Ira M. Woolson, E. M., of Columbia University, New York. Tests by applied loads until destruction and tests by stationary loads, moving loads and vibratory loads in actual practice

Baldwin Locomotive Works, Philadelphia, Pa. Booklet No. 55, being a record of recent construction. This booklet is devoted to a description of the Walschaert Valve Gear now being used on a number of the locomotives manufactured by this company.

Bury Compressor Co., Erie, Pa. Bulletin No. 30, illustrating and describing their duplex and compound air compressors, steam and belt driven.

Sullivan Machinery Co., Chicago, Ill.—Bulletin No. 48-F, for April, describing and illustrating the Sullivan continuous coal cutter for undercutting coal in room and pillar mines.

Niles-Bement-Pond Co., 111 Broadway, New York—Progress Reporter for May and June, describing various new machine tools being placed on the market.

TWENTY-FIVE years ago the United States produced 27,000 tons of copper The production during 1905 was practically 400,000 tons, or more than half the world's total supply. The value of last year's output may be given at $160,000,000.

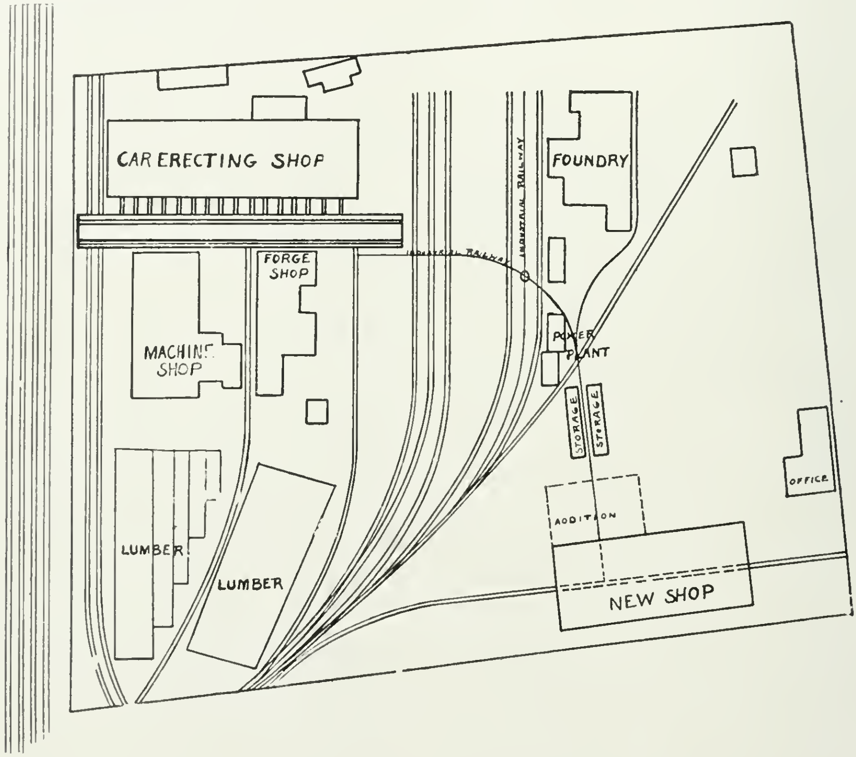
The uses of this metal are steadily growing. It is estimated that by 1920 the requirements of the world will reach 1,500,000 tons The United States will probably hold its present place in the market New deposits are opened from time to time. There are known districts yet undeveloped in the Western mountains, and Alaska is rich in copper. Mexico and Canada are coper countries and send the United States ore and matte for smelting, and pigs, bars and ingots for manufacture

The increasing supply of the metal promises to keep prices within reasonable bounds, while the increasing demand fairly assures ample profits to the owners of copper properties No available substitute has yet been found for its use for electrical purposes, and the employment of electricity increases from year to year. The day of copper has come, and there is every reason to believe it will be a long day.

A HALL of inventions is proposed for the Jamestown Exposition, where undeveloped inventions can be exhibited, the belief being that possibly some new arts and appliances may thus be brought to light.

A MODEL CAR MANUFACTURING PLANT.

The new shops of the Ernst Wiener Company are devoted to the manufacture of industrial railway equipment of every description for mines, quarries, contractors, plantations, brick yards and manufacturing plants. The aggregate floor area exceeds three acres, and the location of the buildings upon a twelve acre lot provides for liberal future expansion.



GENERAL PLAN OF SHOPS.

In erecting the new additions to this plant, great care was taken to embody the latest ideas as regards design and equipment, that they might be up-to-date in every particular.

The location of these shops at Youngstown, Ohio, enables the management to obtain raw material at a very low cost. This material being made at a very short distance from the shops. Furthermore, most of the principal railroads of the country, including the Pennsylvania, Erie, Lake Shore & Michigan Southern, Baltimore & Ohio, Pittsburg & Lake Erie and Youngstown & Southern, center at this point. The shops themselves have a frontage of six hundred feet on the yards of the Penn. R. R., B. & O., P. & L. E., and the Erie R. R., providing unexcelled facilities for shipping product.

The drawing accompanying this article shows the location of the principal buildings. These comprise a new shop, 80 x 200 feet; car erecting shop, 80 x 270 feet; woodworking shop, 80 x 160 feet; foundry, 60 x 110 feet; and a machine shop, 60 x 160 feet; besides numerous small buildings situated throughout the yards and used for storage purposes.

Throughout the plant the transportation of raw material has been well worked out. Spur tracks from the yards of the railroads named above run into the grounds where they branch out into nine sidings reaching to all the principal shops, and one of which leading directly into the machine shop and extending the full length of the building. Besides these standard gage tracks there is provided an industrial railway system connecting machine shop, foundry, car erecting shop, etc.

The building construction is of composite character, brick being used for all the walls; steel girders and columns are employed in the new shop, dividing the wall into ten panels, each containing six large windows. This shop being the newest of the group is, therefore, of most interest. It is exceedingly well lighted and, there being no overhead shafting, a clear headway is provided throughout the entire central portion of the building. The floor is of 4-inch yellow pine laid on slag filling; each machine, however, being provided with a special foundation of concrete. The roof is supported on 10 steel trusses and is covered with asphalt roofing. A skylight runs the entire length of the building, the windows facing east and west. Along the east side a gallery is provided, designed to sustain 200 lbs. per square foot, under which the smaller machine tools are located, being driven by the only line shaft in the shop. This line shaft is operated by a 20 H. P. Westinghouse, Type S, electric motor, and drives nine machines, including two boring mills for large car wheels, two lathes of 20-inch swing, shapers, radial drills, and other small machine tools. All other machines in the shop are provided with their own individual electric motors. It will not be possible here to enumerate all these machines, but the more important ones comprise a 60-ton hydraulic ram driven by a 3½ H. P. motor, one special axle lathe driven by 11½ H. P. motor, two Pels punches driven by 4 H. P. motors, one punch driven by a 7½ H. P. motor, one cold saw, chain driven by a 5 H. P. motor, one combination punch and shears, besides numerous lathes, shears, riveters, small punches, and other small tools. In the south-east corner of the shop is located an Ingersoll-Rand Imperial, Type 11, air compressor, having a displacement capacity of 250 cubic feet of free air per minute when operating at 180 R. P. M. This compressor is gear driven by a Westinghouse 50 H. P., type S, motor, operating at 850 R. P. M., and controlled by a Cutler-Hammer Self-Starter. Air is stored in a 42″x10′ receiver located in a pit near the compressor. From the receiver a 4-inch main air pipe extends underneath the floor floor the entire length of the building, providing numerous one-inch outlets to which pneumatic tools may be connected. These tools form an important part of the shop's equipment since there is a great deal of rivetting and chipping to be done, as most of the small steel cars are constructed of steel plates riveted together. A 5-ton electric crane operates along a central craneway 80 ft. wide. This crane has a lift of 24 ft. and operates at the following speeds: Main hoist, 50 ft. per minute; bridge travel, 350 ft. per minute; trolley travel, 150 ft. per minute. Two 25 H. P. motors take care of the hoist and trolley travel and a 2 H. P. motor is used for bridge travel. At each end of this shop there are large double doors, permitting the entrance of freight cars. Along the west side there are two smaller doors through which an industrial railway leads to the other shops of the plant. As a rule it might be said that rough castings are received at the north end of the shop and that finished product is shipped from the south end.

The material manufactured in this shop consists entirely of steel cars and metal parts, no wooden cars being constructed here as a special shop is provided for that class of work.

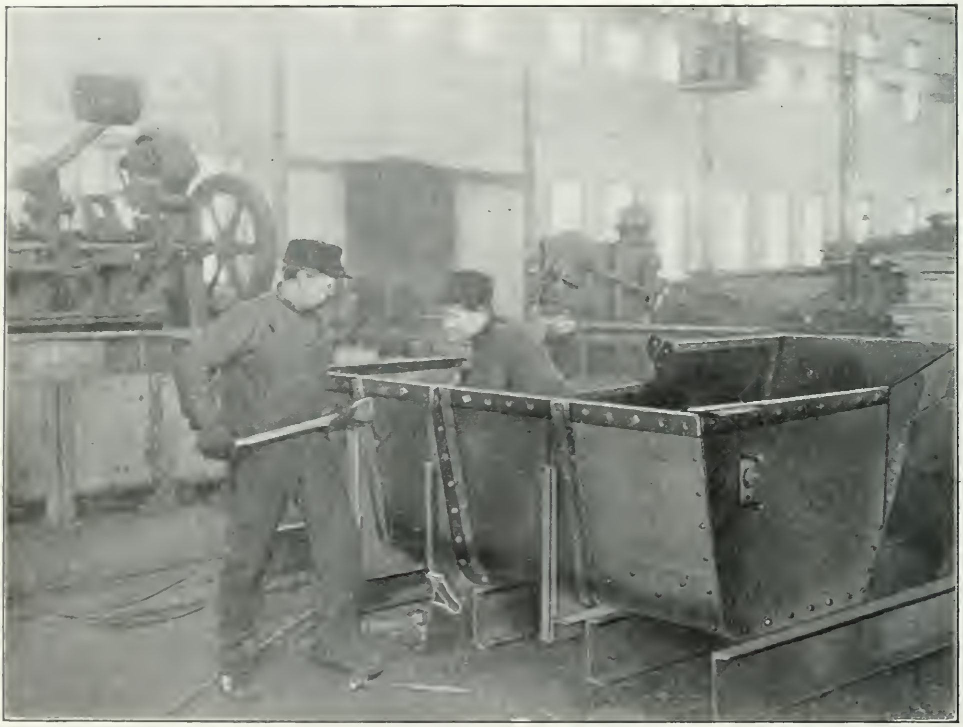
Wooden cars are erected in a large building situated at quite a distance from the new shop and forming one of a group of buildings which comprise the older part of the plant. It is 270 ft. long by 80 ft. wide and contains 16 standard gage tracks running crosswise of the building and having a capacity for assembling 32 standard gage cars at a time.

A transfer table operates alongside this shop in a pit 350 ft. long by 30 ft. wide, and is used for conducting the various finished sections, such as trucks, and frames from the other shops to the erecting shop. Across the transfer table from this shop are located the woodworking and forge shops.

These shops are well provided with machine tools, driven in groups from shafting operated by 25 and 50 H. P. electric motors. The forge shop contains seven forges operated by compressed air under 25 pounds pressure. It also contains steam hammers, a bulldozer, a gang drill, numerous small drill presses, bolt threading machines and automatic bolt and nut machines. Bar iron is stacked just outside the building and large steam engine driven shears are provided for cutting stock.

Back of this group of buildings is situated a large lumber yard containing over one million cubic feet of lumber which is kept on hand for stock purposes.

The foundry, situated north of this group of buildings, is of ample size, 60 x 110 ft., and is used for casting car wheels, brake shoes, fixtures and other parts used in car construction. It is well lighted and provided with moulding machines and machine tools driven by a 20 H. P. electric motor. Fuel and iron are carried to the charging floor by a hydraulic elevator of one ton capacity and having a platform 6' x 6'. This foundry is one of the older buildings, but it is the intention of the management to bring it up-to-date in every particular. Pneumatic sand-rammers, chipping hammers and other improved apparatus will very shortly be installed.



PNEUMATIC TOOLS ARE EXTENSIVELY USED IN THE MANUFACTURE INDUSTRIAL RAILWAY CARS.

Power plant: Motive power for the entire works is generated in a power house, 30 x 40 ft. in size and containing three 85 H. P. Westinghouse gas engines direct connected to 57½ K. W. electric units. This building forms one of the most important installations of the entire group as it provides an exceedingly economical motive power for the works. The engines are run by natural gas possessing a calorific value of 1,000 B. T. U. per cubic ft., and costing but 28 cents per 1,000 ft. As the engines, however, only consume 10½ cu. ft. per horsepower hour, the cost of fuel is therefore only $0.003 per horsepower hour. It would be hard to find a more economical power plant in the country. The engines thus far have been running night and day and have operated most satisfactorily. Cooling water for the jackets is obtained from a cooling pit, having a capacity for 38,000 gallons, and is circulated by means of a centrifugal pump.

The engines are supported on foundations, 5 ft. in depth and each containing 16 cu. yards of concrete. The total weight on each foundation is 36,000 lbs.

Six No. .0000 cables lead from the power plant to the new machine shop; two No. .0000 cables lead to blacksmith and woodworking shops, and one No. .00 cable leads to the foundry. A current of 220 volts is used for both power and lighting.

A general office building, situated at the entrance to the grounds, contains the office of the superintendent, a drafting room, library and a room for making blue prints by the Wagenhorst Automatic Electric Process.

All buildings are provided with fire extinguishing apparatus. Water mains supply water under 60 lbs. pressure to numerous hose boxes, besides which fire pails and extinguishers are met with at convenient points.

LIQUID AIR'S USE

Cheap oxygen is the one important product thus far obtained from liquid air, for which such extravagant prophecies have been made. As the nitrogen and oxygen of the liquid air return to the gaseous state, at different temperatures, it has proven to be possible to separate them by fractional distillation, and as the evaporation of the gases cools the air entering to be compressed in the apparatus, the process is very economical. An idea of this efficiency has lately been given by M. Georges Claude. His plant produces 1,000 cubic metres of oxygen, with a purity of 96 to 98 per cent. in twenty-four hours, and the cost in France is only one-twentieth of that of oxygen from the electrolytic decomposition of water.

The electric arc in which titanium has been distilled has a temperature of about 3,500 degrees C. Making allowance for uncertainty as to pressure in the solar atmosphere, M. Moissan concludes that points on the sun where titanium is seen in the solar spectrum to be volatilized must have a temperature between two estimates of such heat already made—6,590 degrees C. and 2,000 degrees to 3,000 degrees C. The probability is that the latter is nearer to the true heat of the sun than the former. This is very much lower than early estimates.

THE excavation of iron ore by electric and compressed air shovels, instead of steam shovels, is to be experimented with on the Mesabi range in Minnesota; an electric shovel for this purpose is now being built by the Bucyrus Company. It is hoped to economize by generating power at one large central plant, instead of by a boiler and engine on each of the numerous machines. The electric power will be generated at the new Duluth water-power plant. Experiments are also being made with a cableway of about 1,000 feet span, handling grab buckets, the cableway travelling over the ore bed as the work progresses.

To the Editor of COMPRESSED AIR:

Dear Sir:—I am contemplating introducing pneumatic hand drills in my stone quarry for drilling block holes. Can you give me some data and enumerate some of the advantages derived from their use, and supply the name of some manufacturer?

My quarry is a limestone one and the rock is all crushed for road work and concrete.

J. S. C.

A mere mention of the data concerning one of these tools will make the advantages obvious. They weigh from 20 to 24 pounds, and drill a hole 1¼ inches to 1¾ inches in diameter to a depth not exceeding 4 feet. The drill steels which are supplied in any lengths from 6 inches to 4 feet, have a hole in their center running their entire length, the object being to convey a blast of air to serve the double purpose of keeping the steel cool and cleaning the hole, thereby always presenting a clean surface to the cutting edge of the bit. The bit is of the rosette pattern, which insures a round hole and necessitates rotation through only a very small angle, which is accomplished by the operator.

One instance that came under our observation, that will show the phenomenal work these drills will do, was that in which a man with no experience drilled for three hours at the rate of nine feet per hour, hole 1¼ inches in diameter in limestone, but the writer was told that this speed is never maintained under actual working conditions. However, in a quarry in the central part of New York State, a speed of 75 feet per day of ten hours was maintained, and it is of common occurrence to drill a hole one foot deep in two minutes in limestone, and three minutes in hard granite.

The advantages of this mode of drilling over hand work are obvious, but when one recollects that for an 1¼ inch hole three men (one holding steel and two sledging) can make only about 10 feet a day of ten hours, and if a hole small enough for one man to handle the drill and strike is used, then the "powder" cannot be put in the place where it will do the most good, he is forced to the conclusion that his output is costing him money that could otherwise be saved.

To the Editor of Compressed Air:

Dear Sir:—I have just purchased a second-hand straight line air compressor, fitted with a fly-ball governor in combination with an air regulator. Will you kindly tell me how the latter should be piped up? A. S. Beal.

The air connection to the pressure regulator should always be run from the receiver. If this connection were made to the air main or discharge pipe, the pressure so obtained might be below normal, due to the rapidity of flow in those lines. By connecting to the discharge pipe an even pressure is obtained free from pulsations.

ONE of the first air reheaters ever built was designed for use with a rock drill, and consisted of a small chamber attached to and connected with the supply pipe close to the air chest. This chamber was filled with oily waste, which was found to burn freely and add the hot products of combustion to the inflowing compressed air. In the next design, a paraffin lamp was placed in the chamber, and, as before, the products of combustion were taken through the drill along with the compressed air. These experiments, though only carried out on a small scale, were sufficient to demonstrate the advantage of utilizing the heat and gases of combustion; but oil is generally an expensive fuel, and the drill operator, having no interest in reducing the amount of compressed air used by the drill, cannot be induced to bother with separate reheaters attached to each drill.

COMPRESSED AIR is in receipt of a notice from "Purchasers' Guide" of Oswego, N. Y., stating that they desire catalogues of all lines that may be issued by our advertisers and subscribers.

PRACTICAL ITEMS for PRACTICAL MEN.

WATER FOR CONDENSING PURPOSES.

The amount of water required for the operation of either a jet or surface condenser may be easily ascertained if it be borne in mind that there is a certain amount of heat in the steam, and that this heat has to be transferred to the condensing water. A 26-inch vacuum corresponds approximately to an absolute pressure of two pounds per square inch, at which pressure the steam will have a temperature of approximately 126 degrees Fahr. In one pound of steam at this pressure the latent heat is equal to 1,026 British thermal units, and therefore a quantity of water will be required which is capable of absorbing this heat, reaching a final temperature not exceeding 126 degrees Fahr. Assuming that the condensing water is at a temperature of 60 degrees Fahr., we are then able to figure on raising its temperature 66 degrees, which will require approximately 66 British thermal units per pound. If we divide 1,026 units (the amount contained in one pound of steam in the form of latent heat) by sixty-six units (the amount absorbed by 1 pound of water) we find that 15½ pounds of water are required to condense 1 pound of steam. This, of course, is the theoretical amount for the above stated conditions. In actual practice a combination of lower vacuum, and higher initial temperature of condensing water, will require a greater weight of water per pound of steam condensed. In warmer climates it is the custom of manufacturers to require an available quantity of condensing water at least twenty-seven or thirty times the weight of steam which is expected to come from the engine. While in some rare cases this quantity of water will actually be required during the summer months, still the average consumption of cooling water will be found to be very much less.

CARE OF PISTON RINGS

If there is any one part of an engine that is neglected it is the piston rings, or packing rings, as they are sometimes called.

Engines that are intended for high speed and are running almost continuously every day, should have the rings examined at least once a year, and the sharp edges rounded off with a smooth file. If they are snap rings, and are worn a little small, they should be peened out with a light flat peen hammer.

The proper way to do this is to have an assistant hold the ring firmly on a bench block with both hands near the joint, so as to prevent any jar, which might cause it to crack. Start from the center right opposite the joint, and hammer around about half way to the joint, with the peen end of the hammer, striking it about every ½ inch. Then start from the center again and peen the other side the same distance. The rings should then be tried in the cylinder to see how the joints look, but be sure that they are left open about 1-16 of an inch. It is well to try them the full length of the cylinder, as it is often a little smaller in the middle than at the ends. I have fitted rings this way and run them for two years, with good results, but I do not mean to infer that they are as good as a set of new ones. Very few engineers will have a spare set on hand, and are obliged to put the old ones back no matter in what condition they may be. It is well to take all measurements for a new set, so as to have them all ready to put in the next time you are giving the engine an overhauling. The proper way to do this is to run the piston to the crank end. Then with a piece of ¼-inch wire, pointed at both ends, get the exact diameter of the cylinder in the smallest place. Should you file the wire a little short, just hammer it slightly in the center, which will lengthen it again. Send this wire with the exact width and thickness of the old rings to the builder, and have some new ones made.

It is always well to see how the new ones fit the cylinder in the smallest place, before putting them on to the piston, or bull ring, as it might make serious trouble if there were no room left in the joint for expansion.

When the edges of a ring are worn sharp, the oil cannot get where it is needed, *i. e.* the outside surface of the rings, and the walls of the cylinder. Good cylinder oil that will stand a high degree of heat, will adhere to the walls of the cylinder and form a thin film, which will lubricate the rings as they slide back and forth. If the edges are not round, they will scrape the sides so that both the cylinder and the rings will suffer. The engine will pound badly, or there will be a rattling noise in the cylinder, and the engineer will let the lubricator run a little faster, so as to help stop the noise, when perhaps the engine is already getting more than double the oil that would be necessary if everything was as it should be inside of the cylinder.—F. P. KINDER, in *The Engineer's Review.*

The steam pressure that would be allowed on a boiler 50 inches in diameter, ⅜-inch thick with a tensile strength of 60,000, would be found by the rule: Multiply one-sixth of the tensile strength of the plate by the thickness. Then divide this quotient by the radius of one-half the diameter of the boiler. ⅜ inch = .375 inch. Then one-sixth of 60,000 = 10,000. 10,000 × .375 = 3.750. 3.750 divided by one-half of 50 or 25 = 122 lbs. to the square inch pressure allowable.

It pays at every large mine to have a complete machine shop and in some places the magnitude of operations justifies a foundry as well. In the former, repairs of every description can be made from turning out a new rocker pin for a machine drill to welding a stem, or turning a shaft in the lathe. Cars, cages and skips also may be built to advantage in the company's shops. In the foundry all of the heavy castings can be made on short notice, and not only money but often much delay saved. Particularly is this the case at mines in an isolated situation, far from railroads.

If air be compressed in a single cylinder from atmospheric pressure and temperature of 60° F., to a final pressure of 100 pounds, the maximum temperature attained may be 484° F. Stage compression will avoid this, and permit the use of lubricants that would not be possible in single compression. In the latter case, most lubricants would be burned to a charred mass, clogging the valves and ports.

In the conveyance of compressed air it should be remembered that the efficiency is diminished practically as the diameter of the pipes is decreased, which means, of course, that the pipes should be as large an conveniently practicable, with commodious receivers adjoining the air compressors.

CHIPPINGS.

THE Sullivan Machinery Company announces to its customers and friends that Mr. Randolph D. Talmage is appointed local manager at Joplin, Missouri, succeeding Mr. S. A. Allison, who is no longer connected with this company.

The Bury Compressor Co., of Erie, Pa., has secured the services of Charles Wainwright as superintendent. Mr. Wainwright was formerly connected with the Ingersoll-Sargeant Drill Co., of Easton, Pa., and has for the past three years been superintendent of the Blaisdell Machinery Co., of Bradford, Pa. His many years practical experience as an air compressor builder will make him an invaluable addition to the Bury Compressor Co.

The erecting department of the Westinghouse Electric and Manufacturing Company for Manhattan Borough, which until recently was located on the nineteenth floor of the Trinity building, has been moved to the Fuller building, corner of 23rd street and Broadway. This change was made necessary, because the department was in want of more space than it was possible to obtain at 111 Broadway, and also because the uptown location is more suitable and convenient for the construction work, most of the power plants being located within easy reaching distance.

The New Brunswick Refrigerator Co. have recently purchased control of the National Water Tube Boiler Co. of New Brunswick, N. J. The new combination will hereafter manufacture a full line of water-tube boilers as well as refrigerating machinery.

Pneumatic tools are used largely in dressing the stone cut from quarries, these being found well adapted for the fashioning of any desired form of stone. Chisels for lettering and carving are successfully used, as are tools adapted for coarser and heavier work.

Pneumatic foundations and tunnels can be carried out at a depth of 210 feet, below the water surface, according to Messrs. Leonard Hill and M. Greenwood. They experimented on the effect of air pressures up to 92 lbs. by means of a large cylinder, in which they stayed under different pressures for various times.

Channelling machines have added wonderfully to the economics of quarrying. These machines are operated either by electricity or air and travel on a track, on each side of which they cut a deep channel parallel with it. It can be readily appreciated that in getting out marble or other valuable stone, no explosives can be used, and consequently the work of quarrying this class of stones devolves almost entirely on the channelling machine.

Another application of compressed air has been made in a device constructed at the Washington Navy Yard for sponging out the bores of guns. A draft of air of 200 pounds pressure is thrown through the bore of the rifle, the draft being strong enough to blow a block of wood clear out of the bore for a distance of twelve feet or more. Tests of the new device are said to have been attended with highly satisfactory results.

What has become of the fellows that used to argue that labor-saving machinery meant the turning of good men out of work, and a cause of suffering among laboring classes? Who ever saw more labor-saving machinery than is in use at the present time, and when was there ever a time that the demand for skilled labor was better? You hear the call for help from every side and from almost every industry, and not only from those employing skilled help, but also for what is termed common labor.—*Clay Worker.*

It is not the number of blows a machine drill strikes within a given time, altogether, that counts for progress, but also the air pressure back of the drill. In addition to this, the proper manipulation of the machine by the drill runner, is not the least important factor. A chuck-tender of two weeks' experience can scarcely be considered a competent machine miner, yet, not infrequently, such men secure situations with no more experience than that mentioned. Some mine superintendents prefer to break in and train their machine men, claiming that the general result in the end is far more satisfactory.

THE amount of coal produced by undercutting machinery continues to increase in the United States of America. In 1903 there were 6,658 machines in use in the bituminous districts, and they produced a total of 69,620,441 tons of coal, or 28.18 per cent. of the total production of these states where the machines were used. In 1904 there were 7,671 machines in use in bituminous mines, and they produced a total of 70,261,158 tons of coal, or 28.78 per cent. of the total production in the states in which the machines were employed. In 1902 the percentage of machine-mined coal was 27.09, in 1901 25.68, and in 1899 it was 23.

Although the cost of underground pumping by compressed air may be considerably reduced by the use of re-heaters, the conclusion should not be jumped at that it is always advisable to install them. In places where the ventilation is poor they are entirely out of the question. It has been observed that the gases of combustion have a decidedly injurious action on hauling ropes, if allowed to pass up the same shaft, and it is, no doubt, this fact which has prevented more attention being paid to re-heaters. Another point is the fact that most underground air pumps are of small size and a saving of 30 per cent. in operating expenses does not mean much when reduced to dollars and cents.

The air-meter, which measures air as a gas-meter measures gas—or pretends to measure it—has been on sale for two or three months. This invention makes it possible to buy and sell compressed air, distributed from a central plant, at so much a cubic foot. Mine owners thus purchase air for their miners, and it is predicted that some very deep abandoned mines will be worked again. The compressed-air business is new. Wonderful things may yet be done with it. One interesting proposition is the ventilation of the New York Subway by means of highly compressed air, stored in a central reservoir and distributed in pipes. Is the millennium so near?—*A Contemporary.*

The Senate committee on post offices and post roads recently agreed upon an amendment to the appropriation bill, adding $88,735 to the amount to be expended for the extension of the pneumatic tube service, making the total appropriation $1,250,000. The new service was confined by the House provision to Brooklyn, Cincinnati, Kansas City and Pittsburg and the Senate has added Baltimore and San Francisco.

Graham Hood, in the Boston *Commercial* gives ten commandments for the business world. He claims that while they may not embrace everything, so far as they go they are good, sane commandments, and the man who reads them and remembers them may be assured of one thing—it won't do him any harm.

THE COMMANDMENTS.

First—Thou shalt not wait for something to turn up, but thou shalt pull off thy coat and go to work that thou mayst prosper in thy affairs and make the word "failure" spell "success."

Second—Thou shalt not be content to go about thy business looking like a bum, for thou shouldst know that thy personal appearance is better than a letter of recommendation.

Third—Thou shalt not try to make excuses, nor shalt thou say to those who chide thee "I didn't think."

Fourth—Thou shalt not wait to be told what thou shalt do, nor in what manner thou shalt do it, for thus may thy days be long in the job which fortune hath given thee.

Fifth—Thou shalt not fail to maintain thine own integrity, nor shalt thou be guilty of anything that will lessen thy good respect for thyself.

Sixth—Thou shalt not covet the other fellow's job, nor his salary, nor the position that he hath gained by his own hard labor

Seventh—Thou shalt not fail to live within thy income, nor shalt thou contract any debts when thou canst not see thy way clear to pay them.

Eighth—Thou shalt not be afraid to blow thine own horn, for he who failest to blow his own horn at the proper occasion findeth nobody standing ready to blow it for him.

Ninth—Thou shalt not hesitate to say "No" when thou meaneth "No," nor shalt thou fail to remember that there are times when it is unsafe to bind thyself by a hasty judgment.

Tenth—Thou shalt give every man a square deal. This is the last and great commandment, and there is no other like unto it. Upon this commandment hangs all the law and the profits of the business world.

U. S. PATENTS

ESPECIALLY PREPARED FOR COMPRESSED AIR

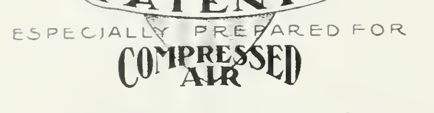
819,179. PNEUMATIC FILTER. EDWARD G. SHORTT, Carthage, N. Y., assignor of one-half to The New York Lime Company, Carthage, N. Y., a Corporation of New York. Filed Dec. 20, 1905. Serial No. 292,611.

819,387. PNEUMATIC TIRE. CHARLES R. TWITCHELL, Los Angeles, Cal., assignor of one-half to James M. Brennan, Los Angeles, Cal. Filed June 20, 1905. Serial No. 266,152.

819,415. AIR-BRAKE SYSTEM. FRANK H. DUKESMITH, Meadville, Pa. Filed Dec. 8, 1905. Serial No. 290,980.

Claim.—1. In an automatic air-brake system, the combination of a brake-cylinder, an auxiliary reservoir, a triple valve and an engineer's valve connected in the usual way, and control-valve mechanism connected to the auxiliary reservoir and to the brake-cylinder and arranged to connect both the brake-cylinder and auxiliary reservoir to the atmosphere.

819,425. PNEUMATIC HAMMER. MARTIN HARDSOCG, Ottumwa, Iowa. Filed July 29, 1904. Serial No. 218,634.

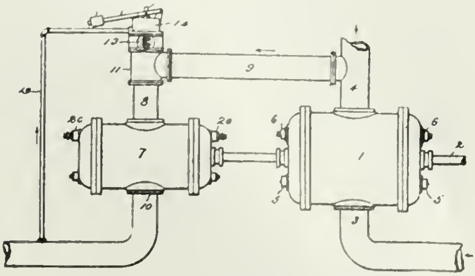


Claim.—1. In a pneumatic hammer, the combination of a main cylinder provided with a pressure-passage leading to its interior, a barrel on the main frame or cylinder forming a shoulder as its forward end, and provided on its interior with a longitudinally extending pressure-passage, a valve-plug outwardly projecting from the forward end of the barrel, a handle for operating the valve, and a reciprocating hammer within the main frame or cylinder adapted to be operated by the pressure admitted by the valve, substantially as described.

819,452. PNEUMATIC CUSHION. VACLAV H. PODSTAVA, Dunning, Ill. Filed Oct. 13, 1905. Serial No. 282,616.

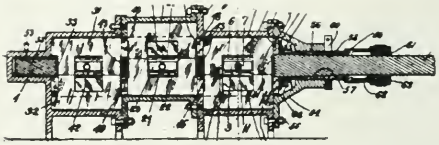
819,503. TIRE FOR VEHICLE-WHEELS. VICTOR E. BELLEDIN, Paris, France. Filed Nov. 16, 1905. Serial No. 287,560.

819,655. AIR-COMPRESSOR. EBENEZER HILL, Norwalk, Conn. Filed Jan. 13, 1905. Serial No. 240,918.



Claim.—1. An apparatus for compressing air having a low-pressure compressor, a high-pressure compressor, a connection between the discharge of the low-pressure compressor and the intake of the high-pressure compressor, a valve in the connection between the compressors that is closed by an abnormally high pressure beyond the high-pressure compressor, and an inlet-valve connected with the high-pressure compressor that is held open, when the pressure between itself and the valve in the connection between the compressors drops below normal as a result of the closing of the connection-valve, so as to render the high-pressure piston ineffective for forcing air forward when the connection-valve is closed, substantially as specified.

819,674. ROTARY PUMP, COMPRESSOR, MOTOR, ENGINE AND LIKE MACHINERY. FERDINAND J. ROCHOW, Brooklyn, N. Y. Filed Oct. 12, 1903. Serial No. 176,637.

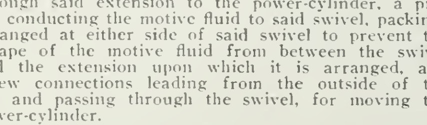


Claim.—1. Rotary apparatus of the class described comprising a plurality of directly-abutting open-ended cylinders having peripheral inlet and outlet ports; a rotatable shaft extended through said cylinders respectively and provided with means to separate said cylinders respectively; piston devices rotatable with said shaft; and connections intermediate the outlet-port of one cylinder and the inlet-port of the adjacent cylinder, to operate substantially in the manner set forth.

819,690. CYCLE-PUMP. DAVID K. BRYSON, Pittsburg, Pa., assignor to Bryson & Howe, Pittsburg, Pa., a Firm. Filed April 28, 1905. Serial No. 257,843.

819,726. ENGINEER'S EQUALIZING AND DISCHARGE BRAKE-VALVE. DAVID M. CASKEY, Jonesboro, Ark. Filed Jan. 28, 1905. Serial No. 243,055.

819,755. ROCK-DRILL. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal. Filed Aug. 10, 1904. Serial No. 220,176.



Claim.—1. In a rock-drilling machine or engine, in combination, a casing, a power-cylinder therein, a cap fixed at the rear end of the power-cylinder, formed with a rearward extension, a swivel arranged on said extension and adapted to admit the motive fluid through said extension to the power-cylinder, a pipe for conducting the motive fluid to said swivel, packings arranged at either side of said swivel to prevent the escape of the motive fluid from between the swivel and the extension upon which it is arranged, and screw connections leading from the outside of the cap and passing through the swivel, for moving the power-cylinder.

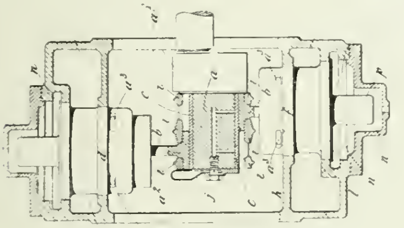
819,756. ROCK-DRILLING MACHINE. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal. Filed Aug. 12, 1904. Serial No. 220,446.

Claim.—1. A dock-drilling machine or engine, comprising a power-cylinder, a drill or bit operatively carried by the cylinder, connections for imparting rotary movements of the cylinder to the bit, and a motor carried by and rotating said cylinder.

819,905. ENGINE. ERNEST C. MEYER, Cleveland, Ohio, assignor to The Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio, Filed Dec. 26, 1902. Serial No. 136,714.

Claim.—1. In an engine, the combination with a piston-cylinder and piston therein, of a valve-chamber having an inlet-port and a distributing-port, and a revolving distributing-valve having means for longitudinally shifting it and formed with a feed-recess which may connect the inlet and distributing ports in one longitudinal adjustment of the valve, a feed and exhaust recess having an exhaust-opening and which may register with the distributing-port in such adjustment and connect the inlet and distributing ports in another longitudinal adjustment and have the exhaust-opening closed, and an exhaust-recess which may register with the distributing-port in such last adjustment.

819,924. AIR-COMPRESSOR. William Reavell, Ipswich, England. Filed Feb. 6, 1904. Serial No. 192,423.



Claim.—1. In an air-compressor, the combination of a circular-shaped frame having a cooling-chamber *m*, an air-receiver chamber *n*, and walls *h*, *k* and *l*; a plurality of main cylinders radially seated in the walls *h* and *k* on two planes within the chamber *m*: an open-ended pilot-cylinder extending from each main cylinder into the air-chamber *n*, a central revoluble crank-shaft and elongated crank-pin; a piston common to each main and pilot cylinder, and a pivoted connecting-rod bearing upon said crank-pin and adapted to transmit its motion to each of said pistons, substantially as described.

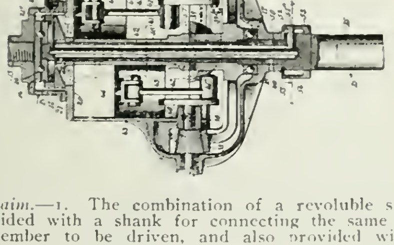
820,007. PNEUMATIC CLEANSING APPARATUS. Albert E. Moorhead, Oakland, Cal. Filed June 6, 1905. Serial No. 263,973.

Claim. 1. In pneumatic cleansing apparatus, a hollow base, having a collecting-tank or receiver therein, an air-exhaust pump mounted thereon, a pipe connection between said exhaust-pump and said tank, an outlet from said exhaust-pump, an inlet-pipe for dust and refuse from carpet cleansing connected with said tank, to discharge into the same, and a device for agitating said dust and refuse mixed with the air and liquid, and forcing it into said tank, located between said inlet-pipe and the tank, substantially as specified.

820,023. DRILL-SHARPENER. George S. Spreyer, Elkton, Colo., assignor of one-half to Edward M. de la Vergne, Colorado Springs, Colo. Filed Dec. 14, 1904. Serial No. 236,803.

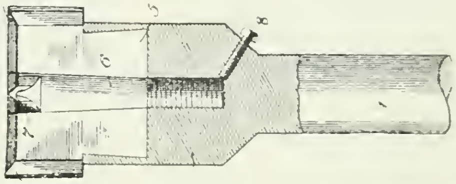
820,104. PNEUMATIC TIRE. Percy W. Fawcett and Edward L. W. Bellhouse, Sheffield, England. Filed Oct. 25, 1904. Serial No. 229,950.

820,345. PNEUMATIC DRILL. Harry Brousseau, New York, N. Y. Filed Oct. 8, 1904. Serial No. 227,675.



Claim.—1. The combination of a revoluble sleeve provided with a shank for connecting the same with a member to be driven, and also provided with a sleeve having an exhaust-passage, a shaft journaled within said exhaust-passage and free to rock relatively to said sleeve, manually-operated mechanism for causing said shaft to rock, a valve-seat disposed adjacent to said sleeve and provided with ports, a revoluble valve mounted upon said valve-seat and provided with passages for registering with said ports, mechanism connecting said shaft with said valve for the purpose of adjusting the same relatively to said ports, and means for admitting an expansible medium to said valve and through the same to said ports.

820,530. ROCK-DRILL. William Sturm, Chicago, Ill. Filed March 11, 1905. Serial No. 249,602.



Claim.—A rock-drill comprising a shank, a plurality of removable cutters arranged on opposite sides of the center of the drill, said cutters being provided with peripheral cutting edges, and a central locking device for locking said cutters in their sockets, said locking device being also provided with a cutting edge located between oppositely-disposed cutters.

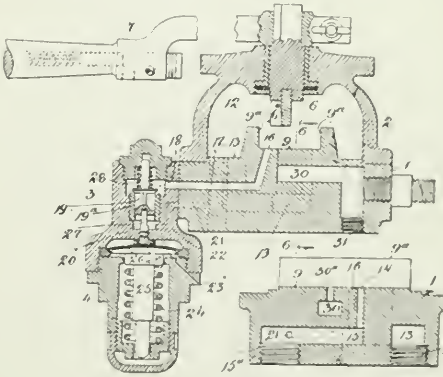
820,549. MEANS FOR COOLING ENGINE AND OTHER CYLINDERS. Edward P. Caldwell, Chicago, Ill., assignor to Charles W. Caldwell, Waterloo, Iowa. Filed Dec. 22, 1904. Serial No. 238,020.

820,673. TIRE FOR VEHICLES. Thomas C. Sanderson, West New Brighton, N. Y. Filed July 14, 1905. Serial No. 260,575.

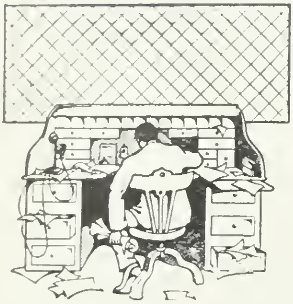
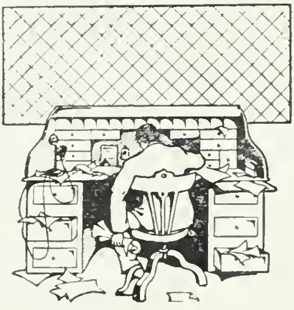
820,695. SUPPORT FOR PISTONS. James Brammer, St. Louis, Mo. Filed June 26, 1905. Serial No. 267,073.

820,740. VALVE FOR CONVEYER-TUBES. Adolph W. Schmidt, Lewiston, Idaho. Filed Feb. 8, 1906. Serial No. 300,184.

820,760. VALVE FOR AIR-BRAKE SYSTEMS. John H. Bleoo, New York, N. Y., assignor to Abraham B. Levy, New York, N. Y. Filed Jan. 9, 1904. Renewed Feb. 14, 1906. Serial No. 301,044.



Claim. 1. An air-brake valve provided with ports and passages, one of which serves for supplying air for the running piston, and a movable valve having ports for controlling the first-named ports and passages, one of the ports of said movable valve being arranged for supplying air there through to one of the first-named ports for the running piston and also arranged to supply air to the last-named port for recharging the system while all other ports and passages are blanked, substantially as described.

Office CHIT-CHAT

¶ Since COMPRESSED AIR changed hands, during the month of April, there has been a gratifying increase in the number of subscriptions. In exact figures the new subscribers represent a gain of 18 per cent.

¶ We feel encouraged. We shall continue to feel so, and we shall continue to put our best efforts into the magazine and to co-operate with our readers to the end that we may keep on improving the quality and substance of the reading pages.

¶ WE WANT MORE LETTERS from engineers and practical men who are having little difficulties with their compressors, drills or tools. We want YOU to send us the findings of your personal inquiries into compressed air matters. Such correspondence is of inestimable value to the compressed air man who, as a rule, cannot find what he wants "in a book."

* * * * * * * * * *

¶ While our subscriptions have been coming in our advertising pages have begun to respond to the new life and force which is being injected into every line of type set up for publication.

¶ Advertisements aggregating TWO AND ONE-QUARTER pages have been received from manufacturers who are fully awake to the power that an INDIVIDUAL magazine must possess.

By INDIVIDUAL we mean that this journal stands alone—it is THE journal in its field and sphere. It is alone in its purpose, alone in the consummation of its purpose, alone in the special influence which it carries, by virtue of its being alone and by virtue of its giving the reader what he wants.

¶ The new advertisers are:

Bury Compressor Co.	¼ page
Peter A. Frasse & Co.	¼ "
Hanna Engineering Works.......	¼ "
Sprague Electric Co.	½ "
Traylor Engineering Co...........	1 "

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¶ THE AUGUST number will be principally devoted to pumping by compressed air, although there will be many miscellaneous items and articles of general interest as well. Among the leading articles will be "Effect of Horizontal Pipes on the Air Lift System," by H. T. Abrams; "Honigman System of Shaft Sinking," by Adolf E. Hartmann, and "Mechanical Refrigeration—History and Practice."

* * * * * * * * * *

¶ By the way, don't you know of some bright young man in a machine shop or manufacturing plant who is anxious to make something on the side? If you do know such a fellow put us in touch with him and we will make a liberal offer for obtaining new subscriptions. WE think the paper ought to pretty nearly sell itself. Perhaps you don't think it's good enough for that yet.

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

AUGUST, 1906.

HOW HORIZONTAL RUNS AFFECT THE AIR LIFT.

WRITTEN FOR COMPRESSED AIR BY HERBERT T. ABRAMS, MEM. AM. SOC. M. E.

In the application of compressed air for pumping, more particularly in connection with the operation of deep wells, the air lift system finds its broadest field, and in this particular work has advanced year by year in public favor, as is evidenced by the number of new installations, both private and municipal.

Briefly, the reasons for the popularity of this method of pumping in water, oil and salt well propositions are the advantages claimed by the trade: Absence of working parts in the well, low maintenance charges, assured maximum yield from any well, and the central plant pumping any number of scattered wells.

All of these claims are acknowledged generally, in fact are indisputable, their being but one reservation in the mind of the engineer and that concerns the question of economy, meaning power consumption alone, without any reference to final savings made through the installation of an economical air lift system.

We have to deal in this article with one of the limitations of the air lift system, and as far as the writer knows, one in regard to which little information is at hand.

It is frequently necessary to deliver water to an elevated tank or reservoir at some considerable height above and distance from the well, in which event it has generally been considered inefficient to make the lift at the well force the water horizontally and end with a lift to a tank, but to just what extent the problem was affected by these conditions has always been a matter of guess work. Confident, however, that serious disadvantage attached to forcing water from a well a long distance, the practice has been, wherever possible, to avoid doing so by substituting either:—

1. Vertical lift at the well high enough to flow the water by gravity to the desired point, employing standpipes (Fig. 1); or,

2. Raise the water to a surface reservoir or cistern near the well and deliver the water above ground by means of an ordinary pressure pump, or a pneumatic displacement pump, submerged directly in the receiving tank or reservoir, thus through a combination of the air lift and pneumatic pump rounding out the whole operation as a complete compressed air system of pumping.

Either of the above methods are preferable to the continued use of the air lift system under such conditions as we are about to consider, but circumstances often prohibit these alternatives or the question of first cost may demand a figure based on making the lift direct with the air lift, and to meet such it is necessary to know what this additional work amounts to.

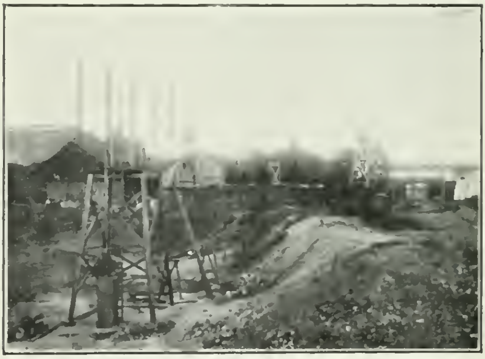


FIG. 1.

The writer recently had occasion to make several experiments along this line in a well 8″ diameter by 800 feet deep, involving lifts in the well of from 13 to 30 feet horizontal runs of 200 and 600 feet with a terminal lift of 50 feet. Standard air lift apparatus was used, which included an Ingersoll-Rand 10 & 10¼x12 Class "A" compressor, air receiver, and the usual piping, and the derrick (Fig. 2) for obtaining the desired lift above surface.

As usual in all air lift experiments, the factors of submergence and velocity of flow figured largely, and a number of tests were made in the endeavor to locate the best points.

For example, in the 200 foot horizontal run it was found that a submergence of 40% required two and one-half times the volume of free air per gallon of water pumped, compared with 60% submergence, and in the 600 foot trial two and eight-tenths times as much air under same relative submergences.

Curve (A), 60% submergence, gives the best performance for a run of 607 feet, showing that to deliver a foot-gallon of water required .0111 cu. ft. of free air, and best rate of discharge to be seven gallons water per minute per square inch area of discharge pipe.

The 207 foot horizontal, 60% submergence, took .0085 cu. ft. per foot-gallon with 8.9 gallons water per minute per square inch area of discharge pipe.

To illustrate the effect of submergence Curve (B) is introduced indicating the results with 40% submergence, 200 foot horizontal run, these conditions, as will be noted giving .0197 cu. ft. free air per foot-gallon as being required, and the best rate of discharge 4.2 gallons water per minute per square inch area of discharge pipe.

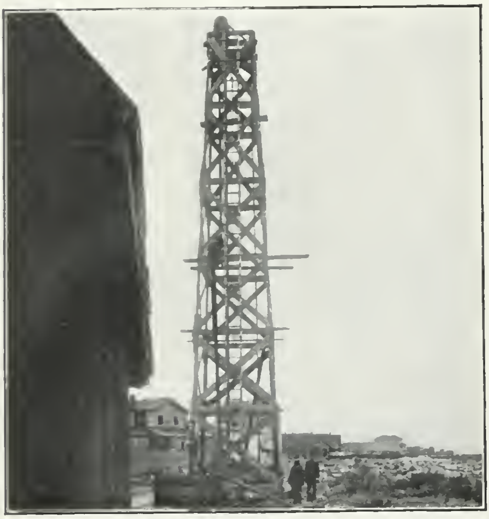


Fig. 2.

It is especially noticeable that increasing the volume of air supplied had little effect upon the quantity of water delivered, in fact the curves show very graphically serious losses following any tendency to force the output.

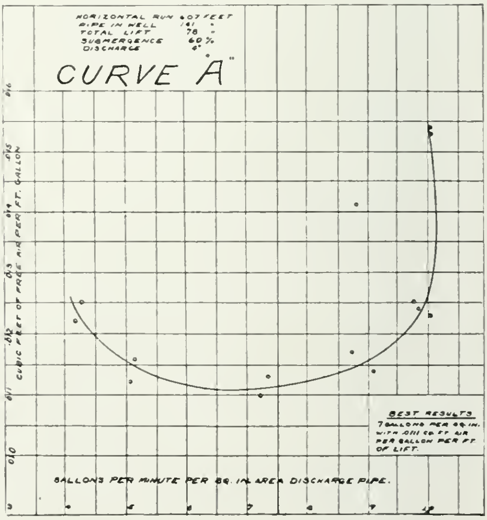
The following tables have been prepared from the tests made, based on average results, and are considered to be safe and conservative:

Cubic feet of free air and gallons per minute per square inch area of discharge pipe for lifts of 13 to 30 ft. at well, horizontal run of 200 feet, subsequent lift of 50 feet.

Submergence per cent.	Cubic feet Free Air per foot gallon	Gallons per minute per sq. in.
40	.0231	4
45	.0176	5.2
50	.0138	6.4
55	.011	7.6
60	.0094	9

Cubic feet of free air and gallons per minute per square inch area of discharge pipe for lifts of 13 to 30 feet at well, horizontal run of 600 feet, subsequent lift of 50 feet.

Submergence per cent.	Cubic feet Free Air per foot gallon	Gallons per minute per sq. in.
40	.0352	3.6
45	.0264	5
50	.021	6
55	.016	7
60	.0127	8



Having these figures in view it may be profitable to make a single comparison of air lift vs. combined air lift and pneumatic displacement pump.

Disregarding the tables and referring again to the curve (A) 60% submergence, 607 feet horizontal run, we observe the factor at the best point is .0111 cubic feet per foot-gallon.

The water discharged being approximately 90 gallons per minute and the lift 78 feet we have:—

90 gals. × 78 ft. × .0111 = 78 cu. ft.

The working air pressure being 52 lbs. we may calculate the horse-power from the common tables in use and the result is 10.9 H. P.

Before proceeding, and in justice to the air lift system, it will be fair to note that if this were a straight lift of 78 feet the air required would have been 90 gals. × 78 ft. × .0062 = 43.6 cu. ft., representing 6 H. P.

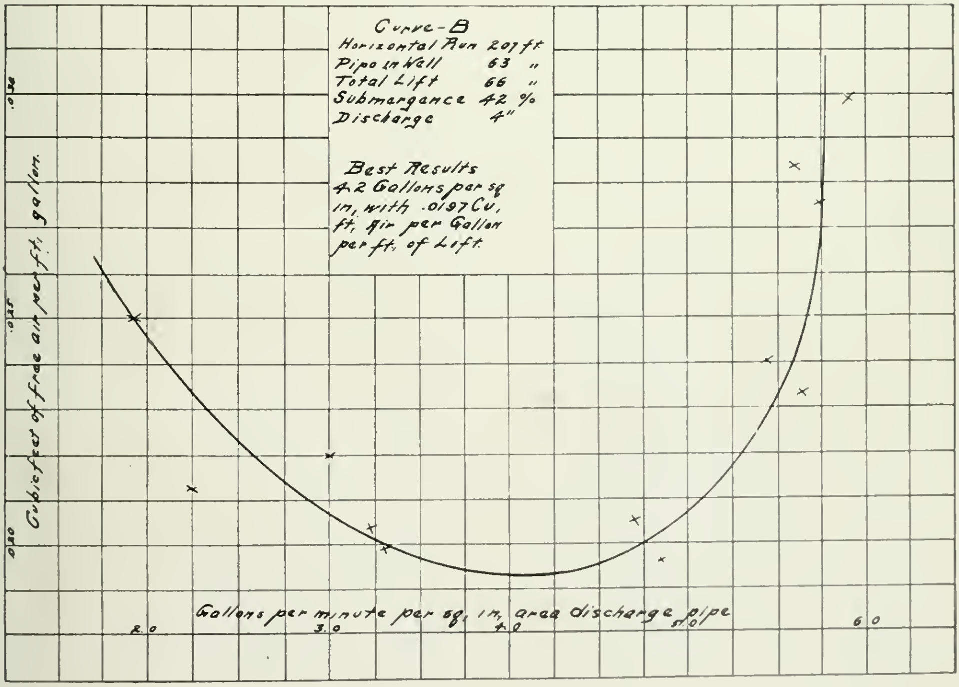
Now taking up the combination of air lift and displacement pump to meet the actual conditions we have:—

1st. A vertical lift of 28 ft. for the air lift system.

2nd. A horizontal run of 607 feet and a terminal lift of 50 ft. for the displacement pump.

The free air required for the vertical lift of 28 feet with the air lift is:—

90 gals. × 28 ft. × .0122 = 31 cu. ft.



The compressed air needed for the displacement pump is a volume equal to the amount of water displaced at a pressure due to the head. The 90 gals. of water to be pumped equals 12 cu. ft. and the pressure required will be approximately 25 lbs., due to the head of 50 ft., plus friction. Reduced to free air, $12 \times \frac{25+15}{15} = 32$ cu. ft. Ten per cent. should be added for clearance and other losses, making 35 cu. ft. Adding the figures for the air lift 31 cu. ft. and displacement pump 35 cu. ft., we have a total of 66 cu. ft. at 25 lbs. pressure, representing 5.6 H. P.

As the horse power required for this work under the air lift system alone was found to be 10.9 H. P. and for the air lift and displacement pump 5.6 H. P. there is a saving of 5.3 H. P. in favor of the latter arrangement under the stated conditions, from which we must conclude that good practice will favor the combination wherever it is feasible to employ it.

THE RETURN-AIR AND PUMPING SYSTEM.

BY FRANK RICHARDS.

The use of compressed air direct for forcing water to any elevation is one of those natural and self-evident propositions which requires no suggesting to anybody in the first place and no urging to at least make a trial of it. Many by different devices and arrangements have taken up and applied this idea, and all have soon found, as a little thought would have assured them without trial, that though the operation might be one of the simplest and the device employed the cheapest the results were after all quite wastefully secured. The raising of water by direct displacement by compressed air, volume for volume, is not a cheap operation, and yet the convenience and reliability of it leads not only to its employment but also to its retention for the service in many cases.

The objection to the system is that when the compressed air has done its work of expelling the water from the operating chamber it is then released with much of its potential energy unused. There are additional losses in the way of filling large clearance spaces and, in many cases, in the uncompensated dissipation of surplus original pressure above that required to balance the water head. The use of twin displacement chambers, required to make the action alternate and automatic, and practically continuous, does not effect the result as far as economy is concerned, indeed often making the waste of air still greater by entailing larger clearance spaces to be filled.

And now comes along another device which has been a long time coming, but which when it comes is at once recognized as the thing. The principle of it is at once self-evident, and the perfect success of it when applied requires no practical demonstration to provoke the familiar exclamation: "Why didn't somebody think of that long ago?"

This is the RETURN-AIR System of Compressed Air Pumping. It is a revolutionary invention and, its field of employment being so extensive, it is also one of the greatest importance.

Its operation, in contrast to that of the too familiar single pipe, direct displacement pump, is that while the old pump will take all that is given to it for raising and delivering a given weight of water and will return absolutely nothing, this new device will take only what exactly pays for the work done, and then *it returns all the change.*

The whole thing can be explained to any one with his eyes shut and without referring to any diagram. It must be premised that this is not a little cheap and handy device to go, for instance, wherever a steam pump might be employed, and to do the same work, but is intended for large and permanent installations, each plant being complete in itself and doing no other work.

There is first of all an air compressor whose entire business it is to operate the pump. There is nothing special about the compressor except that it is in most cases a single stage machine, and it, of course, may be driven by any available power.

The pump part consists of two similar chambers to be alternately filled and emptied. These are submerged in the water to be pumped, or at least located near and below the lowest working level of it, so that the water will always be able to flow into either chamber by gravity. The compressed air is conveyed to the pump by pipes direct from the compressor to each chamber, and each pipe also leads the air, after its work of water expulsion is done, back to the intake of the compressor. The same air is thus used over and over again, provision being made for replacing the little that may be lost by leakage or by absorption in the water. The valve arrangements will be sufficiently evident from a description of the operation.

We assume the pump is actually at work, that one of the chambers is full of water, with air of sufficient pressure being admitted at the top of the chamber, exerting its pressure upon the water and driving the water through a check valve and up a pipe to the point of delivery. So far the operation is precisely the same as with any displacement pump, and when the water is all, or nearly all, driven out, the chamber is then full of air at the highest pressure. The regular operation by the old way would be to now close the communication with the compressor and to open another to the atmosphere, allowing the air to expand down to normal atmospheric pressure, the surplus escaping without doing any more work. Water is then allowed to flow in to fill the chamber again, which drives out the rest of the air, and this chamberful of water is driven out and up by the compressed air as before, and so on.

With the return-air system, however, the air is not let off so easily, but is retained to do a lot more work. The air is discharged from the water chamber and up the air pipe, which by the action of the switch is now in connection with the intake of the compressor cylinder, and whatever pressure this air may have is thus always being exerted upon the intake side of the compressing piston, and the pressure upon this side overcomes an equal amount of pressure upon the compressing side of the piston, or deducts just so much from the total power required to drive the piston and to do the work of compression.

Using the air in this way, its entire expansive force is retained on the credit side of the system. Expansion continues until the air pressure is lower than that of the water which is waiting to enter, the difference of pressure depending upon the speed with which the system is being driven, and then the water enters and drives the air into the compressor intake at this pressure instead of letting it expand further, and thus raises the total mean effective pressure at the back of the piston above that which would have resulted from the expansion alone.

Each return pipe installation is an individuality, with special conditions to be satisfied and calling for special sizes and capacities, both relative and actual. The system is advantageously applicable to both extremes of the possible range of practical requirements, and to all between.

Where the lift is practically constant, as in raising water from a lake or river to a water works reservoir, the compressor and the pump may be so related as to secure all the expansive force of the air with comparatively little of the follow-up pressure, if we may so call it, from the water, but still with the highest possible ultimate efficiency and economy. In any case as the compressor is in immediate touch with its work, there is no loss from over-compression, or from compressing above the actual requirement, as is often the case with the direct displacement systems.

If the return-air system is employed where the level of the water supply has considerable range, as in emptying a large, deep shaft of a mine, the follow-up pressure of the water in refilling the operating chamber will vary constantly with the level, and at all levels will approximately adjust the work of the compressor according to the actual water lift at the time; and although the water must always be lifted under full head, and with the full pressure for expelling the air, the compressing of the air to that pressure will require little or much power according as the return, or intake, pressure at the compressor may be much or little, corresponding to the height of the water supply. With the direct displacement, and no return of the air, there would be none of this compensation either from the re-expansion of the air or from the follow-up pressure of the incoming water, and all the water lifted, whether the level of the supply was high or low, would require the maximum and entirely uncompensated pressure to raise it.

There was an actual case where it was necessary to provide and to have constantly ready the means of emptying a shaft of considerable area more than 300 feet deep and normally full of water, with a tunnel at the bottom of the shaft also to be emptied. This will be at once recognized as a problem easy enough of solution, in a way, but not so simple when speed and economy were to be considered. There was actually installed for this work a hoisting engine and a large cylindrical bucket, say 4 feet in diameter and 12 feet long, to be successively filled and hoisted and emptied. This might strike one as a rather primitive arrangement, but it had at least the merit of using the power with reasonable economy. The varying height did not at all affect the weight of the bucket of water, and the power consumed was therefore always directly as the height, and with engines showing good steam economy the arrangement was not wasteful of power. The bucket arrangement was actually used for emptying the shaft and tunnel once and it worked all right; but nevertheless it has been superseded by the Return Air system. This has been installed because it could show good power economy and could do the required work in much less time, which was the all important consideration.

The shaft here spoken of is shaft 25 of the New Croton Aqueduct, and the tunnel is the portion of the aqueduct which crosses under the Harlem River, near Washington Bridge, New York City.

In our sketch of the operation of the return-air system we have spoken only of the action in one operating chamber. It is understood, of course, that there are two similar chambers operated alternately, one filling while the other is emptying, so that the lift is practically constant. The switch for reversing the connections of the two pipes is operated in different ways according to the work. For a straight, steady waterworks job the switch may be operated mechanically, tripping one way or the other for each given number of revolutions of the compressor, or it may be operated automatically by the fluctuating level of the water supply, and it may also always be operated by hand.

The Return-Air system is adapted to and is in actual use for all kinds of pumping. It seems to decline no job which is possible by any system and it works for the lowest air output. It is especially successful in many lines which are not permissible to the formal mechanical devices. It pumps, for instance, water which is so charged with solid matter that it can only be called semi-liquid. It is in some cases regularly employed for conveying the solids so contained, as sand or marl, the mixture when raised going to settling tanks where the water is allowed to flow off and the solid can then be shoveled and conveyed wherever required.

A list of actual installations of the Return-Air Pumping System shows already a wide and interesting range of successful employment. What the device needs most of all is to be better known.

AIR-LIFT PUMPING.*

BY GUSTAV C. H. FRIEDRICH.

This paper, the last of a series commenced some time ago, will consist of a description of a well recently tested, and some data compiled in a convenient form for the use of those contemplating the construction of an air lift. This information I have gathered from various sources, and it has been demonstrated in practice. The tables will be found convenient.

Several things important to success and economy must be taken into consideration in the installation of this system of raising water. The first is a sufficient supply of water, as this method is not suitable where a small supply only is obtained. The tables should be consulted and the well then permanently piped for the size pipe given in the proper column corresponding to the amount of water furnished by the well. If one well does not furnish the amount of water required, more wells can be put down, and the air furnished by one compressor, located in any convenient place, as has been previously suggested.

Economical compression of air is also essential. Air is a gas subject to rapid expansion under the rise of temperature, and, as we are dealing with volumes at atmospheric pressure, it is necessary that the air should be taken into the compressor at as low a temperature as possible. By the use of a good compressor, economical results can be obtained.

The well lately tested is 300 feet deep, the water being elevated above the surface of the ground 85 feet. When the well is being worked the water level is 44 feet from the surface of the ground, making a total life of 44 + 85 = 129 feet. The water pipe extended down 297 feet, or within 3 feet of the bottom of the well, and from the bottom of the water pipe to the bottom of the air pipe is 5 feet, making a total of 5 + 85 = 377 feet, making a total length of the water pipe, from the point at which air enters to the point of discharge, 377 feet. Subtracting the lift, 129 feet, from 377, gives 248 feet submersion.

Pipes were arranged in the following manner; from the surface of the ground to the end of the pipe extending into the well, the water pipe is 3.5 inches in diameter; to the upper end of this pipe a Y is fastened. Into the center, a 1.25 inch air pipe is put, extending within 5 feet of the bottom of the water pipe. From the side outlet of the Y, a 3-inch pipe extends to the point of discharge. This arrangement would be the same as a 3-inch lift. The well is 8 inches in diameter; the water delivered is 82.5 gallons a minute, or 11 cubic feet; the air used to raise this amount was 81.81 cubic feet of free air, being equal to a little more than 7.43 cubic feet of air to 1 cubic foot of water.

Air pressure was 107 pounds, with a loss of 9 per cent. in its compression. The horsepower required to compress the amount of air used in the operation of this system was 12.134. A percentage of the efficiency of the lift obtained by different submergence will be seen by table I.

Table II shows the size of the well tube, water and air pipes, corresponding to the given quantity of water delivered. These figures

TABLE I. SUBMERGENCE AND EFFICIENCY.

Submergence, Per cent. of length of Water Pipe	Efficiency, Per cent.
60	50
50	40
40	30
33	25
30	22

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*Presented before the Ohio Society of Mechanical, Electrical and Steam Engineers.

have been exceeded by very productive wells, but will often be found too large.

There being 7.5 gallons of water in 1 cubic foot, this number must be used to convert gallons into cubic feet. Table III gives us the ratio of volume of air to water, the submersion air pressure, cubic feet of free air per gallon of water, and the horsepower required for lifting.

Remarks: Special submergence should be used where there is a long horizontal discharge or a great number of turns in the discharge pipe, as shown in the fourth and sixth columns of Table III.

TABLE II. CAPACITY AND PIPE SIZES.

Size of Well in inches	Water Pipe in inches	Air Pipe in inches	Gals. Water per Min.
4	1½	¾	25
4½	2	1	50
5	2½	1	75
6	3	1¼	100
7	3½	1½	150
8	4	1½	200
9	5	2	300
10	6	2	450

In concluding this paper, I wish to say that for some wells which accumulate foreign matter and sand in the bottom, it is a good idea to put a gate valve in the discharge pipe in some convenient location where it can be easily reached. This valve should be closed about once a month and the air pumped up and allowed to blow out all dirt, slime or gravel which has accumulated therein. This will assist in maintaining the efficiency of the well, as any accumulation will retard the flow of water. When a well is blown out or reversed, where the air pressure is high, the water and accumulations are blown out with great force, and it will be necessary to protect objects within 10 or 15 feet of the well from possible injury.

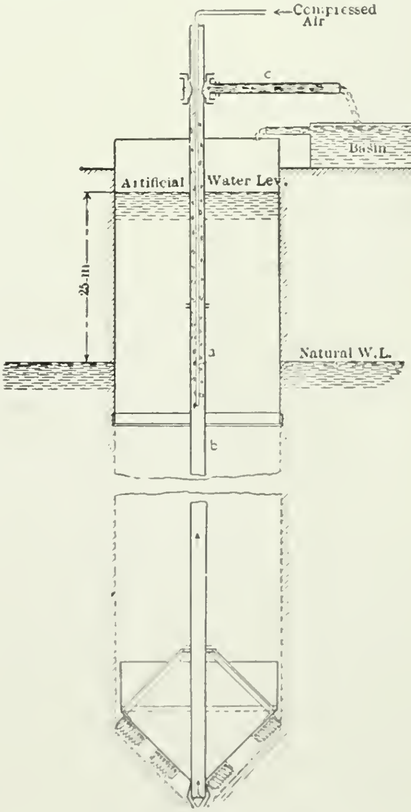
TABLE III. LIFT, SUBMERGENCE AND AIR NEED FOR AIR-LIFT PUMPING.

Lift in feet	Volume of air to 1 foot of water	Subm. equals 60 per cent. total water pipe, ft.	Submergence for special lift, ft.	Air pressure submergence 60 per cent., lbs.	Air Press for sp'l lift submergence 60 per cent., lbs.	Cu. ft. free air per gal. per min.	H. P. per gal. per min.
25	2	38	50	17	20	0.3	0.0184
50	3	75	100	33	44	0.4	0.0426
75	4.5	113	150	49	65	0.6	0.0828
100	6	150	200	65	87	0.8	0.1320
125	7.5	188	250	82	109	1.0	0.1910
150	9	225	300	98	120	1.2	0.2544
175	10.5	263	350	115	152	1.4	0.3150
200	12	300	400	130	173	1.4	0.3808

THE HONIGMANN METHOD OF SHAFT SINKING.*

BY ADOLF E. HARTMANN.

Coal mining has been carried on in western Germany for several centuries, and as a result, all the coal deposits near the surface, when geological conditions were favorable, were soon worked out. Only deep-lying seams, or those which could not be opened on account of the thickness of the overlying quicksand, remained. The quicksand in this region varies from a few feet to 600 ft.; consequently the problem is to sink shafts through this unstable stratum. Three methods are now successfully employed. They are as follows: 1.



HONIGMANN METHOD.

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*Engineering and Mining Journal.

The Sassenberg-Clermont method. 2. The Poetsch freezing method. 3. The Honigmann method.

The first two methods are well known. The third has not been used much outside the German coalfields, although it has proved efficient.

The Honigmann method differs from other sinking methods in the respect that no casing is built until the shaft has been completely sunk through the sand to the solid rock formation. To prevent caving in, Honigmann proceeds as follows:

1. The water-level in the shaft is raised to a certain height above the natural water-level in the quicksand outside the shaft.

2. The specific gravity of the water column in the shaft is increased to about 1.2 by mixing clay with the water. By this means a pressure is obtained, which forces the clay contained in the water into the shaft walls, making a more solid mass of the quicksand. The increasing pressure of the quicksand toward the inside of the shaft is held in equilibrium.

The sludge loosened by the shaft percussion-drill is conveyed to the surface by means of a continuous water flow, rising through the hollow cylindrical drill-rod as shown in Fig. 1. A small gas pipe *a* extends into the drill-rod for a short distance, and through this pipe compressed air is forced, which bubbles into the drill-rod *b*, thereby making the water column in *b* lighter than that in the shaft. As a result the water rises into *b* from the bottom of the shaft, as indicated by arrows in the illustration.

The water and sludge flow through the pipe *c* into a basin, where the sludge is allowed to settle while the separated water flows back into shaft. The velocity of the rising water *b* can be increased by forcing more compressed air through the pipe *a*. Clay is mixed in the basin with the water returning to the shaft in order to keep the water in the shaft at the necessary specific gravity.

When the shaft has been sunk through the quicksand, and has reached solid ground, a casing is built in the usual way by means of iron tubing. In passing through the quicksand constant care has to be exercised to keep the artificial water-level and specific gravity of the water up to the pre-determined standards in order to prevent a caving in of the shaft.

Seven shafts, varying from 12 ft. to 18 ft. in diameter, have been sunk recently in western Germany by the Honigmann method, without any noteworthy accidents. Most of these shafts passed through quicksand up to 600 ft. in depth.

RELATIVE MERITS OF LARGE AND SMALL DRILLING MACHINES.*

BY FREDERICK T. WILLIAMS.

The purpose of this paper is to discuss the relative merits of the large 3⅛-in. machine and the small 2¼-in. tappet machine in driving development-headings; although the data were obtained from cross-cut headings alone, experience has shown that the results are equally true in drifting, raising and winzing.

Recently we drove two parallel cross-cuts through the same formation, using a 3⅛-in. machine at the breast of one cross-cut, and a 2¼-in. machine of the same make at the breast of the other. The results of this work afforded an ideal comparison, since in both cases the headings were advanced through rock practically of the same hardness and breaking-properties; the amount of sludging was equal, and there was no difference in the condition of the steel or the machines, in the air-pressure or in the experience of the operating-crews.

Some operators in the Cripple Creek district contend that there is ground which cannot be handled with the small machine, the holes being too small to contain enough powder to pull the ground, etc. The results obtained in working the property of the Portland Gold Mining Co., however, show that the ground worked by them does not fall in this class. During a period of two years there have been driven, with the small machine, 4 miles and 308 ft. of development-headings, through a diversity of ground, including Pike's Peak granite (a coarsely porphyritic type of granite), highly indurated, andesitic or phonolytic breccia, true massive andesite, trachytic phonolyte, tuffas, and along dikes of decomposed basalt and hard phonolyte; in every instance a satisfactory record was made.

The headings here described were driven through highly indurated, andesitic breccia, having a hardness of from 5.2 to 7.2 and a sp.gr. of from 2.2 to 2.8. The action of the breccia under the drill was not materially different from that of ordinary red granite. The breccia was not as free-drilling as granite, and sludge accumulated very rapidly after a shallow depth of hole had been gained, but it broke better than granite.

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* A paper read before the American Institute of Mining Engineers.

Aside from the usual work of setting-up, drilling, and loading, the machine men or helpers mucked back, cleaning the floor of muck 3 or 4 ft. back from the breast in order to position the column properly. If the "lifters" acted properly at the previous firing, the muck was fairly well thrown back from the breast; but if either missed fire or were exploded before the other holes, considerable muck was left at the breast which required much additional labor. The usual time needed to muck back was 1.25 hour, but this varied considerably. Flat steel 48x96x⅜-in. sheets, were used, from which to shovel the material. These were placed in position 3 or 4 ft. back from the breast by the trammer just before going off shift. The ground broke fine enough to require little or no sledging. A cubic foot of breccia in place will average 154 lbs. in weight as compared with 90 lbs. on the muck-pile, giving an average of 42 per cent. of void space. All the waste was trammed to the shaft 800 ft. distant, and hoisted to the surface. No timber was used in either heading.

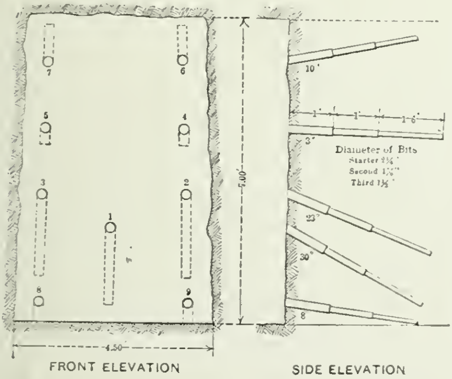


Fig. 1.

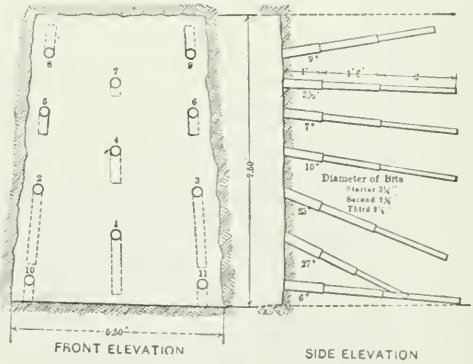


Fig. 2.

The following summary of the results obtained by using both large and small machines has been prepared from the data given in Tables I and II. Labor is the largest individual item. The wages of machine men were $1 per shift, and the addition of the items given under the several heads of Table I shows the total cost of labor performed in each heading. The cost of operating the machines per shift was $3.70 for the large machine and $1.85 for the small machine; these figures, which vary from month to month, include the cost of everything connected with the operation of the machines: engineer's wages, blacksmith expenses, new steel, repairs to the machines, cost and repair of air-lines, etc. The cost of labor, per foot driven, by the large machine was $3.45, and by small machine $2.56.

The cost of explosives, a detailed report of which is given in Table II, shows that the 40 per cent. dynamite costs $0.127 per lb., the fuse, $0.0035 per ft.; and the caps, $0.007 each.

These figures, which include freight, unloading, wages of the powder man, and one-third of the wages of the store-keeper, represent the entire cost of the material, as laid down at the station for the machine men. All fuse burned was in 7-ft. lengths. The number of feet of fuse burned and the number of caps used per foot are practically the same; but the cost of dynamite is $0.78 less per foot in the heading driven by the small machine than in that of the large machine.

The best record for a shift's run, made by the large machine, was 4.08 ft., as compared with 2.96 ft. for the small machine. In drilling these rounds it was found that the large machine had made 3109.56 cu. in. of hole, and the small machine 971.10 cu. in. Comparing these figures with the cubic feet of ground pulled, 1 cu. in. of hole drilled by the large machine broke 0.053 cu ft. of breast, while the small machine gave 0.097 cu. ft. This comparison shows that too much work was done by the

TABLE 1.

	Machine Men	Machine Helpers	Hand Miners	Trammers	Pipe and Trackmen	Total Labor	Cost of Labor per Foot	Number of Machine Shifts Worked	Cost of Operating Machines	General Tramming Cost	Explosives, including Powder, Fuse and Caps	Cost of Explosives per Foot	Cost of Pipe and Track	Cost of Hoisting	Cost of Supplies	General Expense, Bosses, Assayi'g, Surveyi'g, Etc.	Total Cost	Cost Per Foot	Total Tons	Cost Per ton	Number of Feet Driven	Feet per Shift
Large Machine (3⅛″). Cross-cut (5.5′ x 7.5′).																						
5 day run	$40	$35	.....	$22.13	$3.00	$100.13	$3.51	10	$37.00	$0.99	$66.22	$2.32	$11 69	$22.69	$0.79	$22.69	$262.20	$9.20	99.20	$2.64	28.5	2 85
8 day run	64	56	.....	31.13	3.75	154.88	3.33	16	59.20	1.42	90.20	1.93	19.07	32.57	1.14	32.57	391.05	8.41	142.40	2.75	46 5	2.91
7 day run	56	42	.....	28.13	.....	126.13	3.55	14	51.80	1.10	72.84	2 05	14.56	25.25	0.88	25.25	317.81	8.95	110.40	2.88	35.5	2.54
Averages and totals	160	133	.....	81.39	6.75	381.14	3.45	40	148.00	3.51	229.26	2.07	45.32	80.51	2.81	80.51	971.06	8.79	352.00	2.76	110.5	2.76
Small Machine (2¼″) Cross-cut (4.5′ x 7.0′).																						
5 day run	40	....	$0.75	17.25	1.88	59.88	2.49	10	18.50	0.63	36.55	1.52	9.84	14.46	0.52	14.46	154.83	6.45	63.20	2.45	24.0	2.40
8 day run	64	....	.....	31 88	3 75	99.63	2 49	16	29.60	1.09	53.01	1.32	16.40	24.89	0 87	24.89	250.38	6.26	108.80	2.30	40.0	2.50
7 day run	56	....	.....	30.38	3.75	90.13	2.69	14	25.90	1.10	36.71	1.09	13.74	25.08	0.88	25.08	218.62	6.53	109.60	1.99	33.5	2.39
Averages and totals	160		0.75	79.51	9.38	249.64	2.56	40	74 00	2 82	126.27	1.29	39.98	64.43	2.27	64.43	623.83	6.40	281.60	2.22	97.5	2.44

big machine on the breast for the amount of ground broken.

Figs. 1 and 2 show the number of holes drilled, the degrees of pitch from the horizontal, the depth drilled by the starters, seconds and thirds, and the order of firing. The cost of coal before the boilers was $4.40 per ton. Ordinary cross or square bits were used, and all the steel was sharpened by machine. At each sharpening the steel lost ⅛ to ⅜ in. in length. The general tramming cost includes repairs to tram-cars, tram-tracks and the greasing of the cars.

The cost of pipe and track is figured at $0.41 per ft., the 2-in. pipe costing, with connections, $0.10 per ft., the track, together with the spikes, plates and ties, costing $0.31 per ft. Lumber costs $20 per thousand feet.

	Lbs. of Powder	Lbs. of Powder per Foot Driven	Feet of Fuse	Feet of Fuse per Foot Driven	Number of Caps	Number of Caps per Foot Driven
Large Machine (3⅛″). Cross-cut (5.5′ x 7.5′).						
5 day run	491	17.23	872	30.59	116	4.07
8 day run	669	14.39	1,179	25.35	158	3.39
7 day run	554	15.32	804	22.65	134	3.77
Averages and totals	1,704	15.40	2,855	25.80	408	3.69
Small machine (2¼″). Cross-cut (3.5′ x 7′).						
5 day run	264	11.00	672	28.00	96	4.00
8 day run	378	9.45	1,129	28.22	151	3.77
7 day run	262	7.82	742	22.15	120	3.58
Averages and totals	904	9.27	2,543	26.08	367	3.76

TABLE 2.

Hoisting cost $0.243 per ton, which includes all accounts that can be charged to the maintenance of the hoisting engines—such as wages of the engineers, wipers, top-men and cagers, repairs, cost of steam, cables and repairs to shaft. The hoist used is a 500-H.P. Webster, Camp & Lane, first-motion hoist, size 20x48 in., having a capacity for a maximum depth of 2,500 ft., using 5x⅜-in. rope to hoist an unbalanced load of 8,000 lbs., at an average speed of 1,500 ft. per minute.

To supplies is charged the cost of picks and shovels. To general expense is charged the wages of foremen and shift bosses, assaying and surveying, pumping, lighting, including candles, office expense and general repairs on the surface.

The air was furnished by a 50-drill, cross-compound, Ingersoll-Sergeant compressor, having steam cylinders 24 & 44x48 in., and air cylinders 22¼ & 38¼x48 in. The air pressure at the receiver was 100 lb. and at the drills 85 lbs. per square inch.

The bore of the large machine cross-cut is 5.5x7.5 ft., that of the small machine is 4.5x7 ft.; it is held that the increase of 1 ft. in width and 0.5 ft. in height of the large machine cross-cut over that of the small machine cross-cut does not facilitate mining operations.

The merits of the work done by the two machines may be briefly stated thus: The use of the small machine saves 25 per cent. of the cost of labor necessary to operate a large machine foot per foot. The cost of operating a small machine is 50 per cent. less than that of operating a large machine, shift for shift. The general tramming-cost of the large machine cross-cut is lessened 20 per cent. by using a small machine. The cost of explosives per foot driven by the large machine can be reduced 37.7 per cent. by the use of the small machine. The cost of hoisting and general expense of the large machine cross-cut is lessened nearly 20 per cent. by using the small machine.

Greater speed, regardless of cost, can be obtained with the large machine, the small machine being from 10 to 20 per cent. slower. The cost of the large machine cross-cut was reduced 27 per cent. by using the small machine.

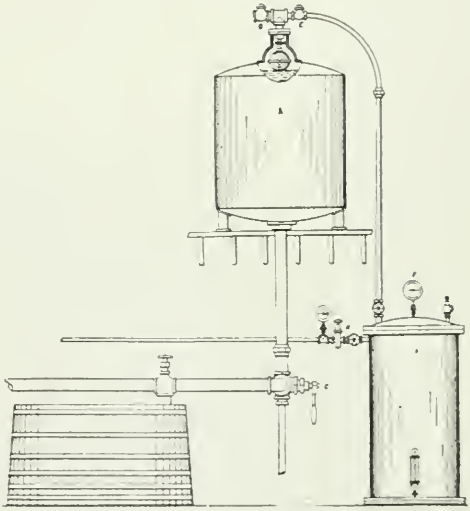
WATER AIR COMPRESSOR

Anton Rehm in *Engineers' Review* describes an original apparatus for compressing air hydraulically. The establishment for which it was designed consumes an average of 25,000 gallons of water per day, drawn from the city mains through a 1½-inch pipe under an average pressure of 60 pounds and discharges into a number of tanks of 1,000 gallons capacity each.

This establishment operates a number of machines requiring compressed air under a pressure of from 2 to 10 pounds. Compressed air is also used for blowing dust out of a number of electric motors.

The illustration shows the compressing device in detail. By placing tank A, having a capacity of 1,000 gallons (or 133 cubic feet) over the water tank room, and a second tank *P*, of 66 cubic feet capacity below the tank *A* in the water tank room and piping them as shown, 3,325 cubic feet of free air will be compressed to about 50 pounds pressure per square inch (which is more than can be used) without the expense of operating an air compressor.

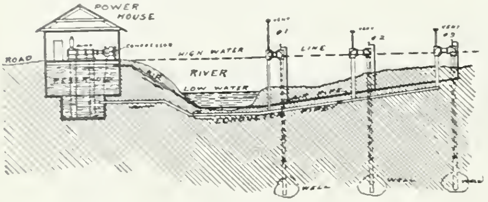
The operation is as follows: Give the handle of the three-way cock *C*, a ⅛ turn, then the water will flow from the water main to the tank *A*, until the float valve closes and in turn discharges the corresponding volume of air through the check valve *E* into the tank *P*. The gage *F* will indicate about 2 pounds pressure. Then turn the handle of the three-way cock to its original position, when the water will flow from the tank *A*, to the water tank and in turn draw in air through the check valve *G* ready for another filling.



In filling the tank *A* with 1,000 gallons of water 133 cubic feet of free air is compressed in the tank *P* to about 2 pounds and by using 25,000 gallons of water per day it equals 25 fillings or the displacement of 3,325 cubic feet of free air compressed to about 50 pounds pressure per square inch deducting necessary losses. This air is drawn out of the tank *P*, through a reducing valve H, under the desired pressure.

MUNICIPAL PUMPING PLANT AT DES PLAINES, ILL.

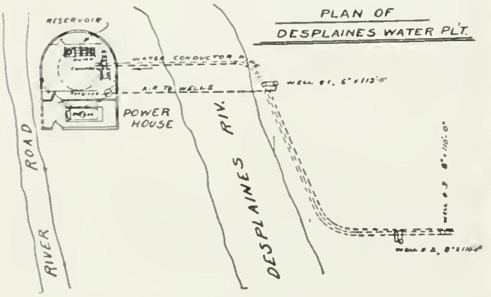
J. Francis Small, in *Municipal Engineering*, describes an interesting air lift plant for municipal water supply. This plant, owing to local conditions, made a departure from general practice as it was necessary to insure against any interruption in its operation throughout the four seasons.



PROFILE DRAWING.

From the profile drawing it will be observed that the reservoir and power house are built together, the walls of the reservoir forming the foundation on which the walls of the power house are placed.

It will be further noted that the reservoir and power house are built on a higher elevation than the level on which the three wells supplying the water are drilled, and that these wells are separated from the power house by the Des Plaines river.



The river is shown at low-water mark, the level at which it flows a good portion of the year. A dotted line indicates a higher level, which is reached in the spring and after heavy rains. When these floods occur the wells become entirely submerged and it would be impossible to pump them if special provision had not been made for so doing.

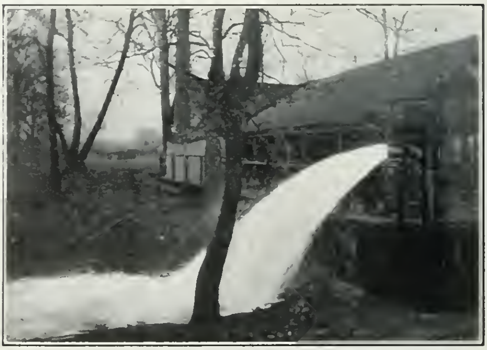
In lifting water by compressed air it is good practice to discharge the air into the atmosphere and get rid of it as rapidly as possible after it has performed its duty in lifting water from the well.

Where long pipe-runs from wells into a common reservoir are necessary a smaller reservoir or receiving tank is usually provided at each well, into which the water from the well is discharged, and from this tank a conductor pipe is run to the main reservoir.

TESTING WELL NO. 1.

The illustration herewith will give a clear idea of this system.

On account of the reservoir at Des Plaines being higher than the wells, it became evident that the discharge pipe at each well would require considerable elevation above the surface in order to raise the water to a sufficient height to permit it to run into the reservoir by gravity, after which the question arose as to the building of a separate reservoir at each well in an economical and substantial manner, and provide against the river flowing into them at high-water mark.



TESTING WELL NO. 2.

The solution of this proposition was to abandon the idea of auxiliary reservoirs and adopt the use of a return pipe at each well. The illustration showing the piping rising from the ground in the form of an inverted "U" will give a clear idea of the method pursued to accomplish this object.

To dispose of the air a vent was provided in the top of the wide sweep "T" forming the top of the pipe riser leading to the conductor pipe. (Note same marked "vent" in profile drawing.) By this form of construction the wells are satisfactorily blown regardless of the river's level and at the same time are closed against interference by the public, yet open to the atmosphere for ventilation.

TESTING WELL NO. 3.

Prior to the Chicago Pneumatic Tool Company installing its compressed air water lift system the citizens of Des Plaines had no regular supply of water on which to depend, 54,000 gallons being all that could be pumped in twenty-four hours.

The guarantee made by the contractors was to install a plant capable of raising 200,000 gallons of water in twenty-four hours. Under test they raised at the rate of 270,000 gallons for several days.

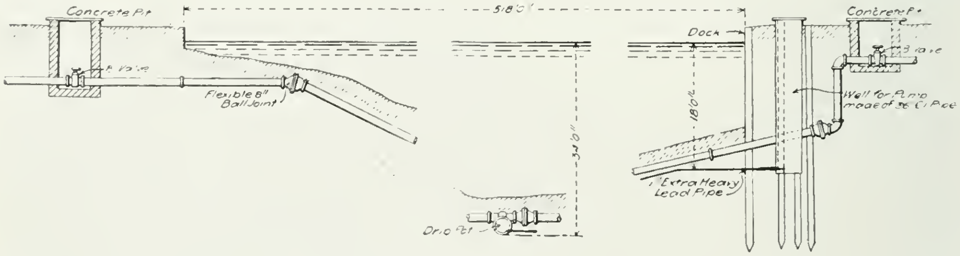
The outfit consists of one 12x12x14 Type G-S-S Franklin compressor, a 36-inch by 6-foot upright receiver, three Chicago Pneumatic Tool Company's special water lift valves and necessary piping, all of which was furnished and installed by the Chicago company. There are two 8-inch and one 6-inch wells, all three of which are about 110 feet deep.

Bids were submitted by the leading concerns engaged in the installation of compressed air water lift systems, and after due consideration the contract was awarded to the highest bidder.

USING PNEUMATIC TOOLS UNDER WATER.

An interesting application of pneumatic caulking tools is described in the April 21st issue of the *Engineering Record*. It relates to the laying of a new gas main by H. M. Byllesby & Co., engineers and contractors, of Chicago, for the Oshkosh Gas Light Co., of Oshkosh, Wis. The main was eight inches in diameter and was laid under the Fox river from Oshkosh to South Oshkosh during the past summer. It was to replace an old iron main carrying low pressure coal gas. The old main had been badly corroded by the action of acids produced from an unusual quantity of cinders which reached the river. The new main is made of standard cast iron hub and spigot water pipe with lead joints, every three inch joint being a flexible one to facilitate the laying and to permit the main to adjust itself to the bed of the stream. The illustration shows the general layout and the difficulties which had to be overcome. A trench for the main was excavated under the river by a diver using a hydraulic jet supplied with water under 140 lbs. pressure.

The joints between the three 12 ft. lengths of pipe were made upon a scow which was anchored at the point where the work was in progress. A flexible joint was made at the same time on each of the mains composed of three lengths of pipe. The scow was anchored over the position, each section thus assembled was to occupy, and the section lowered into place by a derrick. These sections were supported by chains at two points, one just beyond each of the two joints between the lengths of pipe, in such a manner as to keep them horizontal during the lowering. The flexible joints were of the Falcon ball and socket type with bolted flanged connections fitted with a lead gasket between the flanges. When a section of the main was lowered into place at the bottom of the river the flexible joint on the end next to the pipe already laid was made by the diver. The diver made the lead joints with a pneumatic hammer fitted with a caulking tool. The joints made on the surface were also caulked with the same tool, air power being supplied by a Blake compressor on the scow.



Details of Submerged Gas Main Crossing Under Fox River at Oshkosh.

The rock came so close to the surface of the bed of the stream near the middle of the crossing that the pipe had to be anchored to it in order that safety might be insured against displacement. Holes were made in the rock on both sides of the pipe by a pneumatic hand drill, operated by a diver. Expansion bolts were then placed in these holes and strips of iron fastened over the pipe attached to the bolts. After the pipe had been laid, the trench opened with hydraulic jet was soon closed up with silt from the river.

The submerged main was provided with a gate valve at each end on shore in order that it might be cut out of service. A connection with an air compressor was also provided on the river side of one of these valves permitting the main to be tested for leaks. After the laying had been finished, these gate valves were closed and air under pressure of 60 lbs. was turned on to test the joints. Whenever leakage of air occurred a diver went down and recaulked the joints.

The contractors guaranteed leakage, including condensation, not to exceed four gallons per twenty-four hours. An actual test after the main was completed showed the leakage and condensation to amount to about 2.75 gallons per 24 hours. A hand pump at the bottom of the well on the shore was of sufficient capacity, of course, to remove this quantity of water, the suction lift being reduced to reasonable working limits by the well.

WE are going forward with the greatest load of prosperity ever carried by the American people, and the best thing about it is, that the load is pretty generally distributed, so that we may be spoiled a little, but will hardly break down under it the present year.

BLASTING IN NEW YORK.*

BY R. W. RAYMOND.

The recent numerous instances of damage done to persons and property by blasting within the limits of New York City warrant a more vigilant supervision, not only of the handling of explosives, but also of the methods of excavation involving their use. So far as danger to human life is concerned, it may be sufficient to secure care and competency on the part of those in charge; but with regard to the perpetual nuisance of noise, and the peril in which buildings and foundations are involved, something more should be, and easily can be done. Namely, the unnecessary excessive use of explosives should be prevented. The public now submits to the shocks and dangers of heavy blasts, under the impression that these evils are inevitable. But it is perfectly practicable to make excavations and drive tunnels through rock without such catastrophic performances. In tunneling, for instance, deep holes are usually bored at the face, and heavy charges of explosives are fired in them, with great loss of useful effect, due to the disadvantageous direction of the holes. If a vertical cut were made in the center of the face, small holes on both sides, parallel to the cut, would give with light charges a full theoretical effect, "throwing" toward the center-cut, and wasting neither energy nor noise in pure, useless mischief. The thing has been done. Manufacturers of rock-drills are ready to furnish machines which will make the center-cut; and the process, skilfully directed and manipulated, need not be more expensive in the aggregate than the present orgy of mis-directed power. Even if the direct cost were a little higher, it would be more than compensated by the immunity from expensive accidents. At all events, the citizens of New York have the right to insist that this safe and quiet method shall be absolutely required.

If I am correctly informed, this obvious improvement, while it has shown itself to be both practicable and capable of reasonably economical application, has encountered a passive resistance, shown in lack of loyal co-operation, on the part of contractors and workmen. Engineers do not like to quarrel with contractors over points not definitely fixed by specifications; contractors do not like to quarrel with labor-unions; and labor-unions fight, on general principles, all novelties or economies which do not actually increase wages. So there we are; nothing will move all parties but a legal requirement.

This trouble about the excessive use of explosives is an old story to colliery engineers. The persistent demand of the miners' unions, East and West, that they shall be allowed to waste, as dust, all the coal they choose, and be paid for it as if it were merchantable coal, has been disguised under various plausible forms. But, under all these forms, it means simply that without regard to danger of "dust-explosions," loss to operators, or injury to property, the union miner shall be allowed to use unlimited amounts of explosives, if he can thereby obtain more remuneration for equal pains or equal remuneration at less pains.

Whatever may be conceded in rural districts, the real estate of New York City is too valuable to be fooled with in this fashion.

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* Engineering and Mining Journal.

COST OF FUEL FOR ENGINES.

It will be convenient in estimating the amount of coal for hoisting engines and the like, to use the following figures: Allow one-third of a ton of coal for each 10 H. P. per 10-hour shift. This rule holds good for most engines up to 80 horsepower.

In addressing the Glasgow University Engineering Society recently the president, G. T. Beilby, said that there are in Great Britain steam engines and boilers with a yearly output of at least 5,000,000 H. P. The coal consumed by these is not less than five pounds per indicated horsepower, or, on the whole 40,000,000 tons. By the use of gas engines and steam turbines the coal consumption might be reduced to one and one-half pounds per indicated horsepower hour, or, on the whole, to 12,000,000 tons. The saving in coal, therefore, would be equal to 28,000,000 tons, valued at £9,800,000. The cost of making the change need not exceed £50,000,000, or, if the power is to be delivered as electricity, £60,000,000, or respectively £250,000,000 and £300,000,00. Theoretical economies of this kind, he added, were often disregarded; but in the present instance they would amount to over 16 per cent. on the capital expenditure, and still more would result if one takes credit for more efficient plant reducing working costs.

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, Mem. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., . Managing Editor
P. F. KOBBÉ, JR . . . Business Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. AUGUST, 1906. No. 6.

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TUNNELING UNDER DIFFICULTIES.

A great deal has been said in the newspapers of late about the difficulties encountered in the tunnels now under way across the East and North rivers about New York. It is not generally understood that there are being constructed at the present time thirteen distinct tunnels under these rivers. Some of them are of large diameter to accommodate railway trains and others of less diameter for rapid transit and trolley service. That tunnels may be built successfully under these rivers is not an open question because it has been done before. The East River gas tunnel was built several years ago and during its construction practically the same difficulties now met with were then encountered and overcome. In the case of the East River the material is not uniform, some of the time rock being encountered, at others mud and sand, and in some places both rock and mud; that is, part of the tunnel may be through rock and the other part through mud. In the case of the Hudson River the problem of construction is more simple because there is mud throughout and this is the reason why we hear less about trouble in the North River than on the other side. Some thirty years ago Colonel Haskin started to tunnel the North River and before his death he succeeded in building a tunnel about three-quarters of the way across. Fourteen years ago this Haskin tunnel was being constructed by Messrs. Pearson, the contractors who are now building the East River tunnels for the Pennsylvania Railroad. The man in charge of this work for Pearsons was Mr. E. W. Moir, who is now the Director of the East River work. The old Haskin tunnel was recently taken up under the able direction of Mr. Charles M. Jacobs, the engineer who had completed the East River gas tunnel, and it is through Mr. Jacobs' able management that the difficulties in the old Haskin tunnel were overcome and the two headings were joined. We have, therefore, behind us the experience of two tunnels completed across both of the rivers and in nearly all of the present work Mr. Jacobs has acted, and still acts, as consulting engineer. In addition to this the Pennsylvania East River tunnels are under the able management of Mr. E. W. Moir who, since his experience with the old Hudson tunnel, has successfully driven the Blackwall tunnel under the Thames at London.

The only real difference between the tunnels now under way and those which have been completed is that the present tunnels are larger in diameter and in some cases are longer. This does not, however, affect the case further than to increase the cost and to make it a little more difficult so far as progress is concerned to drive through material other than rock. Most of the present tunnels are driven at a greater depth than the old tunnels, but this is an element of safety in that they are less liable to "blow-outs." Compressed air, which is the active agent involved, must be supplied at higher pressures than where the work is done nearer the surface, but these pressures have in no case so far exceeded 45 pounds to the square inch, a figure quite safe and considerably below pressures that have been met successfully in caisson work for bridge foundations and such-like. The trouble which the men have experienced from the "bends" or the caisson disease is what must always be expected in work of this kind. Even with the best care and medical attention workmen in compressed air will at times get the "bends" and in some cases the result is fatal. The work about New York is provided with all the safeguards usually employed in work of this kind. In fact the emergency hospitals and the medical examinations are rather more thorough than usual and it is a matter of note that the supply of compressed air per man at work is larger than in any other work of this kind.

There is, therefore, no occasion for alarm about the difficulties incurred in subaqueous tunneling about New York and there is every reason to believe that these tunnels will be constructed within a reasonable time and with as little loss of life and injury to the men as is possible under such extraordinary conditions.

BLASTING IN NEW YORK.

Everything that Dr. Raymond, the distinguished mining engineer, says on any subject is interesting. We publish in this issue a recent editorial of his, entitled "Blasting in New York City," which calls attention in a lucid and practical manner to the reckless disregard of the safety of property and lives in New York City by blasting methods which have always been used and are now used in the mountains. What is safe in a tunnel driven through the Andes should not apply to work done under foundations of buildings in districts where people live and move and have their being. Tunnel driving has grown to be a question of progress; that is, men try to drive fast regardless of shock and of the quantity of powder used. It is a well-known fact that the so-called "cut" holes in the heading of the tunnel are in America put in 8, 10 and 12 feet deep, filled with dynamite and "blown out" in order to release the cut for blasting the side rounds. As Dr. Raymond says, it is perfectly practicable to make rock excavations and to drive tunnels through rock without producing violent shocks. In fact it is a reasonable statement to make that in the centers of population and underneath buildings, or near foundations, the law should prohibit blasting of rock except in cases where there is a free face alongside of every hole that is blasted. Experts know very well that in bench work less powder is used for the same amount of rock removed and less shock encountered than in heading work. This is because bench work always has a free face or a line of least resistance toward which the blast acts, while in heading driving there is no such line until the center cut has been blasted. It is while blasting this center cut that most of the shock occurs. Machines have been designed and put into practical use which make channels in headings or other placing in the rock just as channels are cut in marble and other quarries. These machines are extremely simple and may be operated by common drill runners. The channels may be cut in almost any position and should be placed where they can best relieve the shock of the blast. As a matter of fact channels might be cut so as to enable the rock to be removed without any blasting. This is done in marble quarries but a reasonable and intelligent amount of blasting made in connection with a proper placing of channels should serve the purpose and enable contractors to remove rock at little, if any, increased cost beyond the present system. The saving in explosives is enormous, and when the men are properly trained and the system has been established, there is no reason to expect greater cost or less progress.

CAISSON DISEASE.

There has been much discussion lately about the numerous cases of caisson disease, or "bends" as it is more commonly called, that have occurred. This disease has been the cause of numerous deaths in the East River Tunnels, now being constructed by the Pennsylvania Railroad and has always been considered a mystery and very little has been known of its cause and effect outside of the fact that it usually attacks workmen who had spent too short a time in the air lock. It has been known, however, that frequently cases of "bends" could be cured by recompressing the patient and then allowing the air pressure to be lowered very gradually to atmosphere.

The New York *Evening Post* recently printed a most interesting editorial on the subject of caisson disease, which is of sufficient importance to be reprinted in full, and we regret that space prohibits us from doing this. The *Post* states that recent autopsies performed upon human beings killed by this disease indicate that the "bends" is caused by air bubbles in the blood, as those bubbles have been found in the heart, blood vessels, and various tissues and organs. Air bubbles may seem very harmless and it may be asked how they are capable of producing such profound disturbances and often death. The realization of the serious consequences of air in the circulating blood is as old as Galen. And the danger of allowing air to enter certain veins in the course of surgical operations is guarded against by modern surgeons. If by any chance air as a bubble—that is, in contrast to absorbed or dissolved air—is in the circulating blood stream, it acts like a foreign body. The bubble may pass along for a distance, but at some point it will block the circulation of the blood by obstructing a small artery. Should the air bubble lodge in a vessel of the brain through which the blood passes to nourish some important center, as that which controls respiration, then the brain center would at once cease to function. The individual stops breathing and death ensues. The same is true of an air embolus in the heart. But if the circulation to centers that are not vital is impeded, the other symptoms of the disease are manifested, pains in the limbs and joints and various degrees of paralysis. In the less severe forms of "bends", complete recovery of health is not unusual, because in the course of a little time the air is reabsorbed into the tissue fluids, and those parts which have suffered as a result of starvation in having the blood stream cut off from them are again restored to normal. Only in the case of the nervous system, where regeneration of injured tissue is especially difficult, do permanent injuries result.

If the man who has been in a caisson for several hours under a pressure of two or more atmospheres passes quickly through the decompression lock—so quickly that the air is not held in solution in the blood, but escapes in bubbles in the tissues—this free air causes, if not death, a train of severe and dangerous symptoms. Physicians have been somewhat slow in accepting the explanation of "bends," probably because the facts seem more tangible to a physicist than to one trained to medicine, and also because the observation of cases in the hospital has revealed little in explanation of the disease and nothing as to means of treatment. In fact, "bends" is a condition which need almost never occur.

Leonard Hill and Macleod, two physiologists of the London Hospital, have repeatedly placed monkeys in a small caisson and subjected them to a pressure of eight atmospheres (117.6 lbs. per square inch) without any apparent injury to the animals. These investigators, however, allowed two hours for decompression from this high pressure, which is much more than is ordinarily used in any engineering construction. It is the belief at present that at least fifteen minutes for each atmosphere of pressure should be taken in order to be within the bounds of safety, but whether this precaution will ever be rigidly observed is questionable; and it would be safe to say that the men themselves, as much as any construction company, would object to a period of a half hour spent in a decompression lock, when there is a possibility that no harm would come if only five minutes were allowed for the operation.

A practical milking machine has been installed on the dairy farm of C. F. Moulton & Son, at Cuba, N. Y., where 24 cows are now successfully milked twice each day by the new apparatus. A combination of the vacuum and compressed air systems is used.

USES OF COMPRESSED AIR.

There is no doubt that there is a much greater future for the use of compressed air for all kinds of industrial purposes than is at present appreciated, and that, as a means of transmitting power over long distances with the use of a reheater at the point of consumption, it offers scope for useful experiment and investigation. The utility of compressed air is not appreciated in this country to the extent that it is in others. We associate its use principally in connection with railway brakes and rock drills. In other countries its use is general for all kinds of industrial work, driving engines, locomotives, conveying parcels through tubes, and in Paris this form of power is distributed not only to factories and electric lighting stations, but is sold, like electricity or gas, to householders and restaurant keepers, etc., for all manner of domestic purposes. We referred a short time ago to the successful application of compressed air for several pumping installations by Messrs. Isler & Co., and in a recent issue of COMPRESSED AIR is given an instance of the success and economy of the air-lift in the field of deep-well pumping as compared with pumps of ordinary design. Two belt-driven pumps, with cranks and piston, giving a double-acting effect with a definite length of stroke, were installed. They were driven by an ordinary portable steam engine and boiler; the compressor used was a second-hand "straight-line" machine of 18-inch stroke. The test was conducted by a well-known consulting engineer, who was employed to make tests to determine which system should be installed. The tests were very thoroughly made, and definitely showed that while the deep well pump raised sixty gallons of water per pound of coal burned under the boiler, the air lift, under the same conditions, raised 300 gallons per pound of coal burned. While it is admitted that a much higher efficiency could have been secured for the pump by the use of an economical steam engine, it must be remembered that the use of a Corliss compound compressor would have given far better results in the case of the air lift.

CHARLES E. TRIPLER.

Mr. Charles E. Tripler, of liquid air fame, died June 20th, at Liberty, N. Y., from Bright's disease, after an illness of two months. The death of Mr. Tripler will remind a great many persons of the remarkable experiments which he conducted and of the extravagant hopes which his work aroused. Up to a certain point the methods of all who have tried to liquify gases have been practically identical, the first step being to compress the gas to a high pressure and the next to remove by a suitable use of cold water the heat developed in that operation. This, however, was not sufficient for the liquefaction of air and various methods were resorted to to reduce the temperature of the compressed air below the liquefying point. Sir James Dewar was accustomed twelve or fifteen years ago to surround the receptacles containing the compressed air with liquid nitrous oxide or ethylene, or something else which is normally a gas. By the evaporation of this substance a degree of cold was produced intense enough to liquefy the contents of the vessel. Such a process was expensive and adapted only to making liquid air in very small quantities. It was Mr. Tripler's ambition to evolve a process by which liquid air might be made on a commercial basis and at low cost. He utilized the expansion of a part of his compressed air to chill the rest of it. His process was, therefore, simpler and less expensive than Dewar's, though not altogether original. It had been employed previously by Linde, in Germany, and by Hampson, in England. Mr. Tripler probably improved the apparatus required and he gave liquid air itself a wonderful impetus in this country.

Mr. Tripler was born in New York City in 1849. His education was received largely from private tutors and, even in his youth, he was interested in laboratory experiments in physics and chemistry. He also devoted much of his time to art, and a collection of twenty of his paintings exhibited in various parts of the country twenty years ago attracted much attention. As soon as his process for liquefying air had been perfected he organized the Tripler Liquid Air Company, capitalized under the laws of Arizona, for $20,000,000. While this company was not a success, it is due to Mr. Tripler to add that while he was sadly mistaken in some of his beliefs, they were honestly held. The reason for his failure was doubtless the fact that he lacked the scientific training necessary to a perception of the fallacies of his own reasoning. This is evidenced by the fact that for a long time he fancied that with machinery driven by liquid air he could manufacture eight or ten gallons with an expenditure of only one.

While liquid air has not as yet been used to advantage commercially there is a chance that it may result in a cheaper process for the manufacture of oxygen than any other, owing to the fact that nitrogen is slightly more volatile than the other gas with which it is associated in the atmosphere. When the compound has been liquefied the nitrogen shows a disposition to evaporate first. How fully this propensity can be utilized in the manufacture of oxygen is yet to be determined, but it illustrates that though liquid air has been a disappointment in a great many ways it is still likely to prove of some practical value.

NEW PUBLICATIONS.

The Northwest Mining Journal.—A monthly magazine devoted to mining and metallurgy. Edited by James B. Adair. Volume 1, No. 4, April, 1906; paper 6¼x12¼; 20 pages illustrated; $2.00 per year.

This journal receives contributions from a considerable number of special contributors and contains articles of value and interest. It covers the Northwest mining field and makes a specialty of news from Alaska, British Columbia, Idaho, Montana, Oregon, Washington and Yukon. The leading articles in the April issue contain among others, "Opening Up of Claims," by A. J. Colquhoun, E. M.; "Tin Deposits of York Region, Alaska," by J. H. Hill, E. M.; "Placer Mining," by Julian A. Becker; "Pyrite," by Judson C. Hubbart, E. M.; "Gold Mining as an Investment," by George K. Rogers. The more important articles are well illustrated and should be of value to the mining engineer.

TRADE PUBLICATIONS.

Chicago Pneumatic Tool Co.—Circular No. 56, illustrating and describing special electrical tools and accessories, such as air cooled, Duntley electric drills, portable grinders, portable pressure blower, etc. The circular also describes Little Giant pneumatic drills, with Corliss valve, Boyer and Keller hammers, etc., etc., etc.

Ingersoll-Rand Co.—Catalog No. D43, illustrating and describing Rand Rock drills and mountings. Catalog No. X136, on Imperial Type 11 power driven air compressors. Bulletin No. 2007, on Imperial piston air drills. Booklet 6A, devoted to Imperial chipping hammers, Haeseler axial valve riveting hammers, Imperial riveting hammers, rotary drills, motor hoists and "Little Jap" and "Little Imp" plug drillers.

Sullivan Machinery Co.—Bulletin No. 51C, devoted to descriptions of the Sullivan "plug" drill for quarrying and contracting work.

C. A. Burton Machinery Co., Northwest Corner of 2nd and Main Sts., Kansas City, Mo.—"Burton's Water Works for Country Homes."

De La Vergne Machine Co., foot East 138th St., New York City.—Ten-page folder, describing the Koerting four cycle gas engine and suction producer as installed in municipal lighting plants, factories and other places.

York Manufacturing Co., York, Pa.—Twenty-four-page catalog, illustrating and describing York vertical single acting ice and refrigerating machines.

Vilter Manufacturing Co., Milwaukee, Wis.—Catolog A, May, 1906. Refrigerating and ice-making machinery.

The Duff Manufacturing Co., Allegheny, Pa.—Sixteen-page catalog, devoted to a description of the Duff ratchet screw jacks, roller bearing and cone bearing; also differential screw jacks. Eight-page booklet describing the Barrett pipe forcing jack for forcing or pulling pipe horizontally under ground.

De La Vergne Machine Co., Ft. of East 138th St., New York City.—Catalog No. 7, devoted to refrigerating and ice-making machinery.

Great Lakes Eng. Works, Detroit, Mich.—Catalog B, devoted to ice making and refregerating machinery.

A very interesting booklet has been issued by the Goldschmidt Thermit Co., 43 Exchange Place, New York, on the subject of thermit and what may be done with it. "Thermit" is a mixture in powdered form of iron oxide and finely divided aluminum. It melts, or liquefies, within thirty seconds after ignition, forming pure iron and slag, in superheated liquid form, and is an ideal substance for welding steel or iron. Slag has the property of instantly hardening upon contact with cooler surfaces and forms a glaze or skin that is quite refractory even to the intensely hot thermit steel. Upon this fact is based the "thermit" process of welding pipes. The liquid steel quickly brings the pipe ends to welding heat and a turn of the cranking screws, used in the process, firmly butt-welds the ends of the pipe. Because of the absence of gaskets and packing, welded pipe is especially valuable for ammonia, brine, steam and compressed air piping; it is also suitable for high pressure water pipes. It will be seen that by this process leakage is made an impossibility and this should be a considerable item in large compressed air plants where leakage, although, perhaps, but a small percentage of the total volume of compressed air used, still amounts to a considerable item when figured as power lost. Rods and bars may be welded by this process equally as well as piping or rails, and it can be done on the ground or in the engine room or almost anywhere, in fact, by means of the simple thermit apparatus described in the booklet mentioned above.

THE Gravity Measuring Coal Chute Co., Richmond, Va., is distributing a pamphlet, well illustrated with half-tones and line drawings, descriptive of coal chutes for locomotives. The delivery pockets are in pairs, each pair containing two or four tons of coal. Pneumatic vertical gates control the filling of the pockets from the storage pockets above. It is claimed that this method lowers the cost of coaling locomotives and allows of a reliable record being kept of the amount delivered to each engine as the pockets measure the coal as accurately as it can be measured by volume.

"Producers and Consumers" is the title of the second document of the Congressional campaign of 1906, issued by the American Protective Tariff League. The pamphlet is a reproduction of the great speech of Hon. Leslie M. Shaw, Secretary of the Treasury, recently delivered at St. Louis. Send postal card request for free copy. Ask for Document No. 85. Address W. F. Wakeman, Secretary, 339 Broadway, New York.

As a "cushioning" device and buffer in rock-drilling the back spring plate cannot be beaten in the views of some experts. It is claimed that there are 50 per cent. less side rods broken on this type of machine than on any other. The breaking of a side rod in itself is a small matter, but the loss of time often incurred by the man in going in search of one is of considerable importance.—*Engineering and Mining Journal.*

INDUSTRIAL.

LUBRICATION OF AIR COMPRESSORS.

The high temperatures and general conditions peculiar to air compressions makes the subject of lubrication with graphite an interesting one to all makers and users of such engines.

As far as is known, from statistics gathered by experts, ignitions and explosions in air compressors are due, primarily, to the character and quantity of lubricant used.

The best cylinder oil available is liable to give off explosive vapor, or "carbonize" and clog discharge valves, so that it must be used very sparingly and with caution.

Soap-suds is sometimes used but owing to lack of "body" large quantities are needed and care must be taken to feed oil into the cylinder when the engine is stopped, or rust will form while the engine is not running. In the use of graphite, however, these difficulties are entirely absent. Graphite is, first of all, the best solid lubricant known to science and practice, is absolutely inert, unaffected by high temperatures and cannot vaporize, ignite, or cause explosion.

It puts an unctuous gloss on surfaces where there is friction, it lowers friction, effectively prevents rust and greatly increases the effective power.

Recognizing these many advantages and the superiority of graphite, combined with a lubricating liquid, over all other methods of air compressor lubrication, the Comstock Engine Company have perfected an air compressor lubricator for feeding graphite and soap suds, or graphite and oil. It is also designed to feed any liquid lubricant without the graphite.

The process is very simple and efficient. The graphite mixed with the oil settles in a compact mass at the bottom of the graphite cup. This mass is in such condition that the oil will not percolate through it, but is caused to flow over the surface of the graphite, a portion of which is carried so that each drop contains the right proportion that is necessary for lubrication.

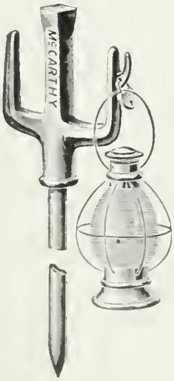
The graphite may also be fed by using a mixture of graphite and soft soap in the lower cup, and water, instead of oil, in the upper cup, so that the use of oil may be reduced to a minimum or wholly abandoned. The soap used in this mixture is prepared especially for this purpose contains no uncombined oil or grease, and is a fine lubricant by itself. The "Graphoil" lubricator is as simple as the "Graphoil" process.

It has a cup for the oil or water, having a valve for regulating the flow, and an opening in the cover for filling, and a brass cup beneath for the graphite.

There is also a valve for entirely shutting off all communication with the air cylinder when desired, and provision is made for equalizing the pressure in the lubricator, so that the flow from the cup is uninterrupted under any variation of pressure in the cylinder. This method of using graphite commends itself to users of air compressors as a first class lubricant at extremely low cost, with the danger of explosion eliminated.

A TRENCH GUARD AND LANTERN HOLDER.

A simple device invented by Mr. D. F. McCarthy, of Waterbury, Conn., is shown in the accompanying cut. It is an ordinary trident made of malleable and wrought iron, 4 ft. 2 in. in length and pointed at the lower end so that it may be driven into the ground. The section remaining above ground, say 2 or 2½ ft., is shaped into three prongs. Where a street is torn up or where there is danger to passers-by, two of these rails are driven into the ground and a board is supported between them, each end fitting into the V-shaped heads of the rails. There is also a device at the top of the prongs to which a lantern may be attached by an ordinary padlock.



The advantages of this device over the old method of building a heap of stones or making a barrier with boards and barrels are numerous. The guard rails are easily driven into the ground, they can be used over and over again, the lanterns are securely locked and there is no danger of their being stolen, this fact alone doing away with one of the causes of damage suits resulting from accidents. Where desired it is possible to build a fence of any length by using several rails. The Manufacturers' Distributing Co., of New York City, are sole agents for the McCarthy rail for the United States.

AN IMPORTANT DECISION IN RECENT PNEUMATIC TOOL LITIGATION.

An important decision was, on May 28th, rendered in London, Eng., in the Chancery division of the High Court of Justice. The suit was that of the Consolidated Pneumatic Tool Company, Ltd., plaintiff, vs. the Ingersoll-Sergeant Drill Company, and Another, defendants. The hearing was before Mr. Justice Warrington and lasted over a week.

The Consolidated Pneumatic Tool Comcomprny, Ltd., had brought suit against the Ingersoll-Sergeant Drill Company on alleged infringements of the former's patents on the Boyer Pneumatic hammer. They sought to enjoin the sale of Haeseler Pneumatic Hammers in great Britain.

The decision was rendered in favor of the Ingersoll-Sergeant Drill Company.

DE LA VERGNE REFRIGERATING MACHINES.

The De La Vergne Refrigerating Co., are placing on the market refrigerating machines operating on the ammonia compression-system. The compressors are double acting and are built in three types, vertical with oil injection, vertical without oil injection and horizontal.

In the first type, oil—known as liquid base—is injected into the cylinder during the period of compression for the purpose of cooling, sealing and lubricating the cylinder, piston and piston rod. This oil absorbs much of the heat of compression and, therefore, economizes the power necessary to operate the machine. A thin layer of oil on top of the piston and one on the lower end of the cylinder takes up all the clearance space and forces the compressed gas completely out of the cylinder before the suction stroke begins.

In the vertical compressor with and without oil injection practically the same general design of valves and housings is used. A special feature of these compressors, and one which every engineer will appreciate is the ease with which the valves can be removed for inspection and cleaning.

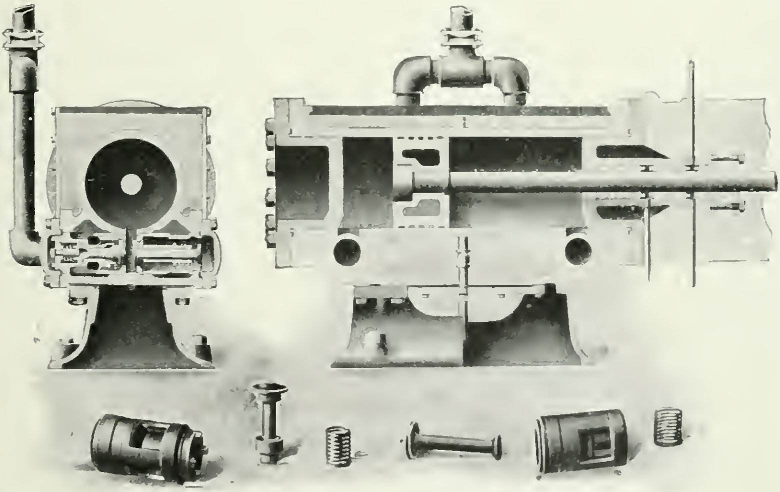
The guides carrying the suction valves and springs are screwed radially into cylindrical suction valve housings ground into radial recesses in the main cylinder casting. In order to inspect the valves it is only necessary to remove the valve bonnets, after which the housings can be drawn out with the facility of a Corliss engine valve. The top discharge valves are set in a single large housing which makes a ground joint with the main cylinder casting and is held in position by the main cylinder head.

One lower discharge valve is set, with its housing, radially into the main cylinder casting. All the valves are held against their seats by springs. Both valves and springs are made as light as practicable, the valves being hollow so that they will offer little resistance to the incoming and outgoing gas.

Heavy valves held in place by stiff springs tend to reduce the back (suction) pressure in the cylinder below that in the suction line and to increase the discharge pressure in the cylinder above that in the condenser, thus diminishing the efficiency of the machine.

The horizontal ammonia compressor is fitted with a water jacket for use with what is known as "dry compression" or that in which ammonia gas is superheated on entering the compressor and is kept dry during compression. These, as well as the vertical compressors without oil injection, may also be operated with "wet compression" in which a small amount of liquid ammonia is fed into the cylinder through the suction pipe.

In the horizontal compressors the same attention is paid to the convenient location of the suction and discharge valves, these being located like the valves in a Corliss engine, but are all in the lower side of the cylinder. This arrangement allows the same port to be used for both suction and discharge, and in this way the extremes of temperature to which the valves are exposed are equalized.



SECTIONAL VIEW OF DE LA VERGNE COMPRESSOR.

The applications of refrigerating machinery have increased to such an extent and have become so varied that refrigeration now forms a complete branch of engineering by itself and no one style of machine can possibly meet all the demands of modern cooling installations.

The De La Vergne Machine Company builds a number of different styles of machines. Among these are steam driven and belt driven machines, each class being built with one or two ammonia compressors. The steam driven machines are built vertical or horizontal, simple, tandem compound and cross-compound, depending on the capacity and space for the installation.

A NEW COLD AIR MACHINE.

A new cold air machine has recently been placed on the market by Messrs. T. & W. Cole, Ltd., of Park Road Ironworks, London, E., England.

This machine has many interesting features, among which simplicity, safety and ease of working should be mentioned, and the fact that it produces a dry cold winter atmosphere in a tropical climate without the aid of any chemicals, nothing being required but the power to work it and the small amount of cooling water for circulation.

This machine should not be confused with the cold air machines so much in vogue in the early eighties. Although the cold air system was the first commercially successful form of refrigeration, its rate of progress was barred by the faults displayed by the earlier machines in their inability to get rid of the moisture before the air was expanded, thus causing large quantities of snow, which partly accumulated in the valves of the machine and caused unsatisfactory working, the remainder being discharged into the rooms causing dampness when the temperature rose above freezing point.

These faults have been successfully combated in the present machine, which is capable of extracting all of the mechanically suspended moisture from the compressed air before the same is frozen, thus rendering the product a perfectly dry cold air, devoid of any snow or moisture, and enabling machines of a very small size to be built and successfully operated for the cooling of rooms containing food, or, when used in conjunction with fan ventilators, for cooling living rooms, etc.

By this system, the air, after being compressed and cooled in the compression cylinder, is still further cooled, and particles of moisture separated from it, in its passage through the cooling chamber, and it is afterwards led to a drying chamber, in which it is caused to pass, by a circuitous route, around the intensely cold walls and ribs of the expansion cylinder, and deposit its moisture thereon, in the form of hoar frost, before being admitted to the expansion cylinder, in which it is caused to do work in driving the piston, which is attached to the crank operating the compression cylinder; thereby converting its remaining heat into work, and producing a correspondingly low temperature about 150° F. lower than when it was taken from the outside atmosphere into the compression cylinder.

The importance of thus ridding the air of its moisture while in a compressed state is, that it enables machines to be built of a much smaller size, and it can be successfully operated without any of the old troubles of the passages or rooms becoming blocked with frozen moisture.

The moisture which is extracted from the air in its circuit round the cylinder is automatically drained off at the end of the day's work by suitable drain cocks.

Many of these plants have been built and are working successfully in all parts of the world, and those which are erected in the Argentine, dealing with the excessively humid atmosphere of those parts, are giving great satisfaction in producing perfectly dry cold atmospheres for the various uses to which it is applied.

These compressors are built with both cylinders lying horizontally side by side, or in vertical models as desired, and suitable for stores for keeping of meat and other produce at a low temperature, and for all other purposes for which a refrigerating machine is required.

THE TRAYLOR ENGINEERING CO. IN MEXICO.

Mr. Samuel W. Traylor, President of the Traylor Engineering Co., has just returned to New York after an extended business trip to Mexico. One of the most important results of Mr. Traylor's trip was the conclusion of negotiations by which the firm of Victor M. Braschi & Co., of the City of Mexico, have taken an exclusive agency for the products of the Traylor Engineering Co., in Mexico.

Victor M. Braschi, the head of this firm, is one of the best known mining and metallurgical engineers in Mexico, and the house which he has established is equally noted. Mr. Braschi is a graduate of the Columbia School of Mines, of the Class of 1881. He has had an extensive experience in ore reducing and other branches of his profession, and has in his employ a large corps of first-class engineers, who look after the business of his house in every part of Mexico. Victor M. Braschi & Co., are also the sole representatives in Mexico of the Ingersoll-Rand Co., the A. S. Cameron Steam Pump Works, and the Erie City Iron Works. In adding to their business the representation of the Traylor Engineering Co., they make a connection which is very desirable for both business houses, as well as for their customers. The Mexican house will carry in stock a large line of the products of the Traylor Engineering Co., and will handle no other make of this class of machinery. They will represent the Traylor Engineering Co., fully so that the customers of that Company in Mexico can feel at full liberty to entrust their business to Mr. Braschi and his representatives, with an assurance that it will be handled with skill and fidelity. The Traylor Engineering Co., had in view a large extension of their business into Mexico and other export countries when they chose the site for their new works at Allentown, Pa. This location besides having a general advantage because of its ready supplies of raw and manufactured materials and trunk line railroad connections is particularly advantageous in its situation for export business. Freight from Allentown can be put f. o. b. at the seaboard cheaper than from New York City. Besides making the arrangement mentioned with Victor M. Braschi & Co., Mr. Traylor succeeded in landing several very important orders during his Mexican trip.

REFRIGERATION BY MECHANICAL COMPRESSION OF ANHYDROUS AMMONIA.

It is only of comparatively recent years that the art of Mechanical Refrigeration has been developed through practical improvement, and has come into not only extensive, but almost common use. We will not enter into the history of the early efforts, and description of the processes attempted along these lines, but will state that experience has developed that the most practical method, and the most successful, is by mechanical compression with anhydrous ammonia as the agent.

This system has proved remarkably successful and has virtually supplanted all others, and what were seeming failures originally arose from faults in design and construction of the necessary machinery, the fact having been appreciated all the while that it was the really correct system for lowering of temperature.

The Eclipse Refrigerating Machine for this work is of novel design, and consists of two vertical single-acting compressor pumps driven by a horizontal steam engine, all parts forming one structure.

The compressor pump is so constructed that it perfectly receives and expels the full charge of gas. No other can do more than this while many do less owing to faults in construction and design.

Each pound of dry ammonia gas discharged by the compressor is capable of accomplishing a definite amount of refrigeration and the maximum pounds of gas compressed for the minimum pounds of steam used in the engine of a refrigerating machine is the real index of economy.

The important feature of this machine is the compressor pump.

The compressor pump cylinders, being of vertical style, are relieved from the weight of the moving pistons with the consequent friction, and thus obviating the rapid and unequal wear of the bore and piston heads.

The gas compression is effected on the up stroke, and the space below the piston is subjected only to the low suction pressure of the gas, ranging from 0 to 35 pounds, hence the piston rod stuffing box packings are easily kept tight without undue friction and wear of the piston rod and an important saving of ammonia.

The suction valve of large area, is located in the piston head, and being balanced by a spring, presents no resistance to the gas which flows into the vacant space above the piston on its return stroke, under the pressure and velocity due to evaporating temperatures of the refrigerating system.

A cushioning chamber with a spring assists in closing the suction valve promptly and noiselessly as the up-stroke begins, the imprisoned gas being gradually compressed until it equals the condensing pressure acting upon the discharge valves located in the pump dome, then discharge begins.

The gas parts with more or less of the heat of compression through the walls of the cylinder; the dome and cylinder being enveloped by a water jacket, through which cold water is constantly circulating. This not only prevents superheating of the gas during compression, but also carries off much of the heat, materially assisting the condenser, and cutting down the gas resistance to a marked degree, below that which would be present without its use.

The safe operation of the piston, metal to metal against the top cylinder head and the expulsion of the full charge of compressed gas without danger, is secured by the movable pump head, of what is termed a safety head, being a valve of the full size of the compressor bore, through the seat of which the piston may pass without injury.

This safety head does not regularly operate as a valve, the working discharge valve being in the centre of the safety head, and fitted with cushioning chamber and spring, securing prompt and noiseless operation.

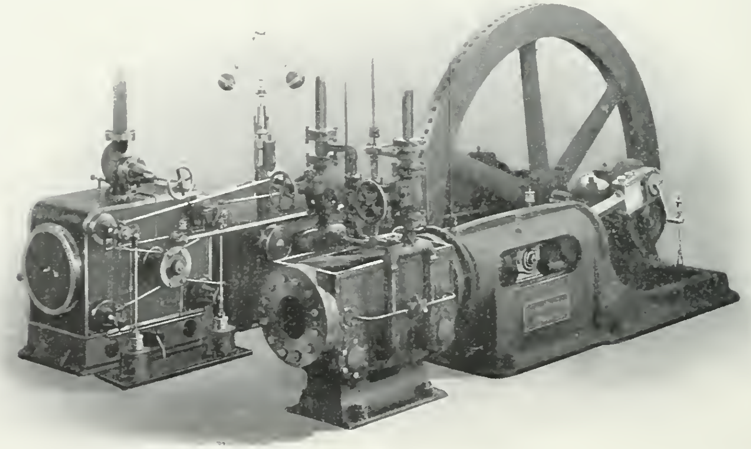
The safety head, with its discharge valve, valve guides and valve seat is self-contained and independent of the pump cylinder, rendering the whole valve mechanism convenient for repairs, removal, or replacing by duplicates without loss of valuable time.

In case of accident to a compressor pump the stop valves on the suction and discharge of the disabled one may be closed and the other pump continue to work, the disabled pump being examined and repaired at leisure.

The proper proportions and sizes of engine to drive a gas compression pump of a given size, under the conditions of its use, as well as the perfecting of such engine that it will do the work with maximum economy in fuel and minimum wear and tear calls for a large experience, to establish the best adaptation.

In this machine, the steam engine is an integral part of the machine, and incorporated in the structure, the construction being such that the engine and pump are self contained.

The engine rod connects directly upon one of the pump crank-pins, and the relative position of engine and compressor is such that a delivery of the power of engine to the pumps is effected during the maximum compression, and in the most perfect manner possible securing economy of transmission; and uniform motion being maintained through the heavy flywheel.



ONE TYPE OF ECLIPSE REFRIGERATING MACHINE.

The wearing and bearing surfaces have adjustments for compensating, and are of the most liberal extent, the main crank shaft being supported in three bearings of rigid stability, and located with best references to the demand of power transmission, shaft alignment, and the avoidance of destructive strains.

In connection with the installation of a first class refrigerating machine for Cold Storage, Abattoir, Packing House, Chemical Works, Brewery, Ice Factory, etc., it will be in order, to secure the highest attainable efficiency, that the Condenser system, Cooler system, Ammonia and Vaporizing systems, Valves, Connections, Tanks and all details of the outfit, be given the most careful consideration of the engineer, and a perfect adaptation made to the general details of the duty required.

The triple pipe brine cooler is especially adapted for use in cooling the circulating brine to the low temperature required in connection with the operation of freezing systems with storage rooms. In its operation the annular space between the intermediate pipe and inside of the outer pipe, takes the current of warm brine discharged by brine circulating pump and passing thence through the inside pipe of the cooler goes out to the brine delivery pipe system.

The annular space between the inner pipe and inside surface of the intermediate pipe being connected with the ammonia liquid feed and gas returns, secures the rapid and efficient heat transfer and vaporization due to surroundings of rapid brine currents, attains the lowest temperature with the higher economical pressure of return gas. Many of these coolers have been installed with most gratifying success in accomplishment of the results sought for.

The Eclipse Refrigerating machine is manufactured by the Frick Company, Waynesboro, Pa.

AN ENGLISH AIR COMPRESSOR.

A new air compressor is being put on the market by Messrs. Thomas White and Sons, of Paisley, and one is being installed in the new shops of Lilybank Boiler Works, Tollcross. The new machine is of the low speed type, which the makers consider gives the highest efficiency. The example referred to has a steam cylinder 15 inches in diameter and an air cylinder 15¼ inches in diameter, the length of stroke being 24 inches. Working at 100 revolutions, it is capable of compressing about 500 cubic feet of free air per minute. The features of most interest are the air cylinder and the methods of governing. The valves, which are made of nickel steel, are light and are of small diameter, but combined give a large port area. This the makers find gives a higher efficiency than a few valves of large diameter. By a new arrangement the piston passes partly over the valves, so that there is really very little lost space at the end of the stroke, while it is impossible for a valve to drop into the cylinder in the event of it breaking. The valves are all interchangeable, and can be instantly removed by unscrewing a covering brass cap. In the action of the governing arrangements, the inlet pipe closes when the pressure in the receiver rises to 100 pounds, and the compressor then works in a vacuum. At the same time a small piston is operated, acting on a double-beat throttle valve shutting down the steam until the compressor is only just moving. With this arrangement, and with the ordinary high-speed governor on steam end, a double check is effected. The steam cylinder is fitted on the compressor with a Meyer expansion gear, enabling the steam to be cut off at any point from ¾ to ⅞ of the stroke, even while the compressor is running. The White compressor is to be employed for supplying power for pneumatic caulking and drilling tools, of which the new works will have a great number.

PURIFICATION OF COMPRESSED AIR.

In the use of pneumatic tools and the operation of all devices where compressed air is the motive power, there are failures of the apparatus due to the presence of scale, moisture and dirt in the air.

Numerous devices are used for eliminating this objectionable material. Large reservoirs at the air compressors and in some cases at the outlets around the shops are used to give the moisture time to settle. Screens are used which will hold back all particles of dirt that cannot pass through the mesh. Again, in order to clean the air more effectively we find a double screen packed with some fibrous material. This last method makes a very effective device, but accumulated dirt and moisture tends to stop the free flow of air.

A new device for purifying compressed air, the Derby Dust Collector, is now being put on the market by the Derby Manufacturing Co., of Burlington, Iowa. This device is particularly novel in that it uses no screens, but depends on centrifugal action to purify the air. The collector is made in one casting, and has two chambers, an upper separating chamber and a lower collecting chamber. At the bottom is a plug for cleaning. The plug supports a pedestal and cap which holds in the collected material. The air enters the upper chamber at the side, which gives a whirling motion. This action throws the dirt out to the sides of chamber and is drawn down into the lower chamber. The dirt would be drawn up through the vortex of this whirling body of air were it not for the cap which is placed in the path of this vortex. The purified air at the center of the upper chamber goes out at the top part of casting. This form of collector will purify the air of all material that has a specific gravity heavier than the air. It takes the collected material out of the air path and gives a free passage way for the air at all times. Where there is much moisture accumulating, a petcock is used for more readily draining the collection chamber.

The collector is small and adapted for use at the outlets of air pipes where it will give the maximum efficiency in keeping the dirt and moisture out of the apparatus that is being operated.

In the operation of air brakes on passenger and freight trains it is essential to have the brakes on all cars operate as nearly simultaneously as possible. The accumulation of dirt and moisture in the valves makes this simultaneous operation uncertain. This collector keeps all foreign material from passing from the pipes to triple valve, consequently it increases the efficiency of their operation and decreases the amount of cleaning and repairs.

SCIENCE LIBRARY OF THE PRATT INSTITUTE.

The applied science reference room of the Pratt Institute Free Library (Ryerson street near DeKalb avenue, Brooklyn) has for its object the aiding of those engaged in any trade or industry, irrespective of any connection with Pratt Institute. Hundreds of questions arise every day, in the factories and shops of a city, which could be answered from some printed page. It is the intention of the reference room to supply this need as far as possible, sometimes with books, very often with periodicals or transactions, and again with trade catalogues.

In the room set aside for this work in the Free Library of Pratt Institute are taken nearly a hundred trade and scientific papers, giving the latest news of the industrial world. There are besides over fifty of the labor union papers, of which a file is preserved. The most important of the periodicals are bound, and these bound files contain much material that can be found nowhere else. The publications of the United State Patent Office are kept here also and are used daily. The collection of books includes up-to-date publications in various industries, such as electrical engineering in all its branches, plumbing, manufacture of textiles, industrial chemistry, gas engines, the making of cement, and so forth and so forth. The books in this room are not allowed to go out, so that anyone coming is sure to find the book he wishes to refer to, if it is a part of the collection. The library has, however, a good collection of books in these subjects for circulation, often duplicates of the books in the applied science reference room. The room is in charge of Mr. Edwin M. Jenks, whose work is to help those who are looking up any question that lies within the province of this room.

A large collection of trade catalogues furnishes the very latest information in many lines, and is being enlarged constantly. The library will get any trade catalogue in print, at the request of any user of the library, if it is obtainable. One new feature of the room is a collection of mounted cuts of machines and mechanical devices. These may be used in the room or taken away to work with, if desired. A man looking up a new form of chuck, for example, will find a score of cuts showing different chucks, and among these may well find some that will be of service to him.

Men studying in the evening schools, those preparing for civil service or other examinations, lawyers, and men of various interests, will find this department of use. The room is open every day except Sunday, from 12.30 P. M. to 9.30 P. M., and can be used between 9 A. M. and 12.30 through the library office.

Ores and Metals announces that from this time on it will be published by Reinert Brothers, of Denver, Col. Under the new management the paper has been enlarged and considerably improved both in appearance and in the quality of its contents. Those who know the present publishers have no doubt that the improvement will continue. The new *Ores and Metals* will be edited by Mr. Carl H. Paddock.

The object of piston valves originally was to take the place of large slide valves which could not be made tight and were therefore ineffective. In action the piston valve decreases the friction and increases the port opening for the same space occupied by the valve. A typical shape of a piston valve is a D slide valve wrapped in the form of a cylinder.

PRACTICAL ITEMS for PRACTICAL MEN.

AIR COMPRESSOR GAVE MOIST AIR.

Air compressors, as most engineers know who handle them, sometimes cause a "bunch" of trouble. The plant that I have charge of has been running about two years, and among a lot of first class apparatus a new compresser was installed of the compound type, having cylinders 18 inches in the low side and 12 inches on the high side with a 12-inch stroke, belt-driven.

When I started this compressor everything ran all right, but the air was very moist, sometimes getting so bad that it could not be used on the air hoist in the foundry or on the pneumatic drills in the machine shop, and it was up to the engineer to furnish dry air. The receiving tank would sometimes fill up to ¼ of its capacity with water, and I was wishing that Bill B. Banger was around to help me find the trouble.

One Sunday I took off the heads and found that the high pressure cylinder was full of water, while the low pressure cylinder was dry. I then examined the cooling chamber which is located between the low and high pressure cylinders, and found that full of water also. Then I began to see light.

The trouble was caused by the drain pipe from the cooling chamber being connected into the main drain pipe in the engine room. This main drain pipe received the water from all the pumps, condensers and engine drips in the plant. The compressor was provided with a governor which was placed on the air intake pipe. When the ball on this governor is down the compressor takes air and discharges it until the desired pressure is obtained. Then the ball rises, the intake valve closes and the compressor runs under a high vacuum.

My trouble was that every time the compressor ran under a vacuum, when the valve on the drain pipe on the cooling chamber was open, it drew all the water that was in the drain pipe into the compressor, and from there it found its way into the receiving tank and caused trouble.

I disconnected this pipe from the main drain pipe and the air has since been perfectly dry, excepting in rainy, or real cold weather, when it may get a little moist, but not enough to cause any trouble.

A. B. M., in Engineers' Review.

PRESSURE ANNUNCIATOR.

A new pressure annunciator with which there is said to be no danger of failure to operate the air mechanism properly has just been perfected. The new instrument is guaranteed to warn the operator whenever the air pressure falls below or exceeds certain predetermined standards. The device can be adjusted to the exact low or high air pressure that is desired. When the air pressure drops below the low pressure point previously determined, the annunciator, which is generally installed on the storage pipe line leading to the engineer's brake valve, blows a continuous whistle for 15 seconds. When the air pressure exceeds the high pressure point previously determined, the whistle sounds continuously until the excessive air pressure is reduced to the normal high pressure point. The annunciator also operates as a pop or relief valve, and will discharge to the atmosphere the capacity of the compressor, should the compressor become short-circuited, or if the operator is unable to stop it, thus preventing the burning out of electrical apparatus, or the blowing up of pipe lines or reservoir. It is nine inches in height over all, and two inches in diameter. It will insure an even braking pressure at all times, and can be used upon any airbrake system in operation at the present time.

LEAKY valves in pipe lines are in most cases due to the abuse of the valve. There are a number of ways in which this abuse occurs. When the line is laid cement is improperly used, gets into the pipe and then lodges on the valve seat. Again, the pipe is sometimes threaded longer than is necessary, with the result that it is screwed against the partition of the valve, injuring it. The lighter valves are sometimes sprung by the wrong applicaton of pipe wrenches, while the attempt to strain leaking stuffing boxes, instead of repacking them, is often the cause of much injury to a valve.

THE PNEUMATIC TOOL.

In the old shops—and the lapse of a few years makes things "old" in this progressive age—the machinery was all heavy and stationary. Elaborate and powerful devices were necessary to bring large pieces to the place where alone it was possible to perform some necessary operation. Now, owing to the progress of invention, we move the tool itself about. Often it can be made so small as to be held in the hand, so that the ease and rapidity of work have both been greatly multiplied. This has been due in great part to the introduction of pneumatic transmission. Says Mr. R. Emerson, writing on the subject in *The Engineering Magazine*:

"The great variety of uses to which air power can be put has made its development rapid and extensive and its effect on prevailing practices and methods has been so marked as almost to revolutionize every important line of modern engineering. Stone cutters, rock drillers, motors, hammers, yoke riveters, hoists, lifts, presses, carpet cleaners, sand blasts, painting machines, conveyors, bolt nippers, jam riveters, flue cutters, holder-ons, air jacks, sand rammers, bell ringers, sand sifters, fire forges, brazing and welding flames—these are a few of the less well-known uses of compressed air.

"Pneumatic and electric motors do not 'generate' power; they turn into useful work the energy transformed through them. Both electric and pneumatic motors are of such recent development that many practices that ought to be obsolete still prevail, especially in railway shops, where competition does not exert the same stimulus as in commercial shops.

"The shops of the immediate past had a main shaft driven by a Corliss engine. This shaft drove all the machine tools. There was either a mechanical or a hand crane—or none at all—over the assembling floor. Present practice drives generators direct by high-speed 'automatic' engines; takes the current to large 20 or 30-horsepower motors (relegated to the rafters in the shops), each driving a 'group' of machines, through main and countershafts, some heavy machines having individual motor drive; and also installs an air compressor, reservoir and piping, with motors and hammers for use on the floor and outside.

"While it is probable that individual and group drive will be retained much as at present, the impending advance in shop betterment with increase of capacity, indicates that many heavy operations will be done by portable tools (whether light electric or air, or the heavier electric-driven machines carried on trucks or transferred by crane) avoiding the effort of moving the mountain to Mohammed. It is this phase of the question that interests us, for it means a transformation not only of work done by hand to work done by power, but also transplanting of work done in the machine shop to work done on the floor, and the savings and economies to be effected will be considerably greater than those obtained through individual group electric machine drives— greater even than those obtained by high-speed steels. For example: if it takes 14 hours to set up a job and six to do it, of which during less than three a high-speed tool is actually cutting, a saving of 10 to 12 hours might be realized by moving a portable tool to the part to be repaired or machined.

"A few years ago (and even in some shops to-day) all drilling, tapping, chipping, calking, riveting, reaming, flue rolling, grinding of joints, cutting, beading, valve-seat facing, ramming, etc., was done entirely by hand, and there was no such thing as an air-lift to handle work for heavy machines; to-day all progressive shops are dependent on air for economical production."—*Stove and Hardware Reporter.*

IN working iron bars up into a chain, it is easy to see that the longer each indididual link, the less will be the number of welds, and the cheaper the resulting chain in first cost It is sometimes claimed that each weld is a source of weakness, and that the chain containing the least number will be the stronger. This is not true, for the longer the link, the greater will become the knuckling action at the ends when going over sheaves and pulleys, and the larger the sheaves must be if the chain is to work upon them without undue wear.

THE following rule is a good method for determining the safe working load of a chain; D = diameter of iron in eighths of an inch; $D^2 \times 0.111$ = safe load in tons. This gives for a ¾-in. chain a working load of $6 \times 6 \times 0.111 = 3.996$ tons.

CHIPPINGS.

FOR removing sand from small brass castings, hydrochloric acid one part and water ten parts makes about the best solution that is used in ordinary practice.

Music is playing an important part in the digging of the Isthmian Canal. Laborers from the West Indies are all accustomed to sing as they work, and bosses who are capable of leading a chorus have much greater success than men who do not have that faculty.—*N. Y. Times.*

With a Central America stage setting, attractively semi-nude natives in the background and the principals dancing a May-pole dance with streamers of red tape, it only needed a dash of music to give the finishing comic opera touch.

It is said that the United Steel Corporation contemplates the installment of air compressors on all of its big steamers. The air compressor has become an important part of all wrecking outfits, since the advent of the steel steamer with a double bottom, and the big steel corporation last fall had several opportunities for the prompt use of compressed air in forcing the water out of the bottom compartment.

The Rix Compressed Air and Drill Company, San Francisco, E. A. Rix, manager, has established itself temporarily in Grass Valley, where arrangements have been made with the Taylor Foundry and Engineering Company to allow the Rix men to work in the shops on both old and new work and on drills. Certain machinery in the Rix shops in San Francisco was destroyed by fire, and is being rebuilt at Grass Valley.

The Traylor Engineering Company has recently received orders for two blast furnaces from clients in the Northwest. The size of these furnaces is 46" x 255". They are to be equipped with the Giroux Hot Blast Top which utilizes heat which is usually lost in the ordinary blast furnace practice. The use of this equipment reduces the coke charge ordinarily used from three to six per cent., according to the amount of sulphur in the ore The company has an order for two other furnaces for British Columbia, 46" x 204", and another order for two furnaces for a Mexican Company, each 42" x 160", and another for a New Jersey Copper Refinery 42" x 60". In fact their works are so completely flooded with work that they are working night and day. Their foundry department is particularly crowded. They are turning out from 30 to 40 tons of castings daily, and as soon as their new addition to the foundry is completed, will have a capacity of 75 tons of castings daily. They expect to have the addition in full operation on or before August 15th.

Now navigation is made more safe by ringing a bell placed under a lightship or light house—the ringing done at will by means of a tube carrying compressed air. The water, being a better conductor of sound than air, carries to a great distance and the ship is fitted with a microphone standing in a closed vessel of water next the keel. A wire from the vessel leads on deck and is connected with a common telephone receiver—the whole giving distinct sounds independent of atmospheric conditions at marvelous distances. Thus the sea as well as the air is made the medium of wireless telegraphy and another great advance is put upon firm foundations promising increasing usefulness.

Compressed air employed as motive power in collieries at a distance from the shaft bottom is theoretically less efficient than electric transmission, on account of the thermodynamic loss of available energy. There is often a large leakage of air in long pipes One of the chief advantages arising from the employment of compressed air plants in coal mines is security from dangerous accidents.

—*Inland Operator.*

They don't know anything about *theoretical* efficiencies in coal mines: only *bank* efficiencies count. Compressed air is employed first of all because it pays: second, because nothing else will do its work: third, because it is always to be depended upon: fourth, because there is so little loss in transmission or by leakage: fifth, because the air is a good thing in itself: last, but not least, because it is a preventive rather than a cause of dangerous accidents.

The German Railroad Union offers every four years prizes for improvements in railroad appliances and methods. This year 7,500 marks are offered as first prize, 3,000 as second and 1,500 as third for inventions and improvements affecting the construction and maintenance of the railroads, the same for those affecting rolling stock; and a first prize of 3,000 marks and two prizes of 1,500 marks each for improvements in administration methods, operation and statistics and for publications of notable value. The Union suggests some of the subjects which are felt to need improvement, though the prizes will not be confined to these Among these suggestions are: Mechanical apparatus for firing locomotives; improvement of steam car-heating apparatus, especially for long trains; hose coupling for air-brakes, in which cut-off cocks may be dispensed with, without affecting the automatic working when trains break in two; apparatus for communication between trainmen and the locomotive, especially for long passenger and freight trains without continuous brakes, and also in passing through tunnels; a critical consideration of the present condition of the motor-car question, and of the running of light trains either by motor-cars or locomotives; simplification of the methods of dividing receipts from freight passing over more than one line, and of other freight accounting. The objects competing must have been put into use (or the writings published) between July 16, 1901, and July 15, 1907. Any such improvement must be in use on some railroad of the Union and be approved by such railroad. The applications for competition must be made between January 1 and July 15, 1907.

At the twenty-first ordinary meeting of the Society of Arts, held recently, Prof. Thomas Oliver, physician at the Royal Infirmary, and professor of physiology at the College of Medicine, Newcastle-on-Tyne, England, read a paper, illustrated by lantern slides, on "Bridge Building by Means of Caissons," with special reference to a modern disease called "compressed air illness."

Describing in detail caissons and the work carried on by their use, the lecturer explained how the compressed air and other conditions affected the workmen, and produced the malady referred to, and in his conclusions he urged the absolute necessity of a shortening of the shifts, and of the length of time spent by the men in the caissons as the air pressure is increased.

Experience, he added, had shown that young men between the ages of 20 and 30, who were temperate, whose tissues were still elastic, men who were of spare rather than of stout build, not only did the work better, but were not so liable to caisson disease.

The London *Tribune* states that the successful use of liquid air as a cooling agent has depended to a great extent on Sir James Dewar's admirable device of vacuum vessels.

Liquid air boils at about 200 degrees Centigrade below zero. Thus, ordinary surroundings in a room are very hot compared with it, and if this heat is allowed to get access to the liquid air, it will rapidly boil away, and be dissipated. The problem is, therefore, to construct a vessel which shall, as far as possible, prevent conduction of heat to the liquid within. This can in some measure be accomplished by woolen wrappings and by glass vessels with several successive walls. But, as Sir James Dewar showed in the early days of liquid air, a space exhausted of air to the uttermost forms a far better partition than any material substance. Radiant heat can, of course, pass through the best vacuum—and it is well that it can, for otherwise we should receive no heat from the sun. This fact makes the complete heat insulation of liquid air impracticable. But a vacuum partition prevents the passage of heat by conduction, or by air currents, and these are the causes which chiefly contribute to the loss of liquid air when kept in an ordinary vessel. In order to jacket liquid air with a vacuum, it is necessary to put it in a double-walled vessel, all air being pumped out from the space between the walls. Up till recently these double-walled vessels have been made of glass, in the form of two concentric globes, united at the neck, so as to have an air-tight space between them. This space can be exhausted and hermetically sealed. Liquid air can then be kept in the inner globe. Ingenious and useful though these vessels are, their use is attended with considerable inconveniences.

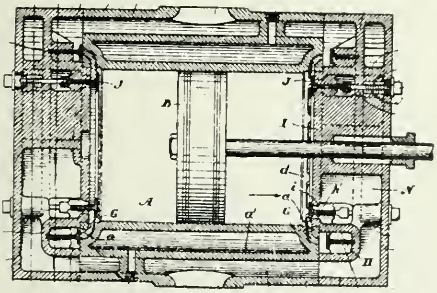
Sir James Dewar has just shown how these objections may be overcome by the use of metal vessels in place of glass ones. This may seem a simple and obvious step, but is not by any means so. The great difficulty in the use of metal is to get a good vacuum in the space between the walls. Almost all metals contain a certain amount of gas locked up in their pores, and this they slowly give out, spoiling the vacuum thereby. None but the very best vacuum is of any use for the purpose, and the extraction of every trace of gas out of the pores of the metal by an air-pump is an interminable process. To overcome this difficulty, Sir James Dewar has made use of the property of charcoal which he discovered—its power of completely absorbing gases at low temperatures. A few fragments of charcoal are placed in the hollow space between the walls of the vessel; as soon as liquid air is poured in, this charcoal gets cooled to a very low temperature, and absorbs any residual gases in the space between the walls. The vacuum soon becomes good, and for preservation of liquid air these vessels are not inferior to the glass ones.

The points in favor of compressed air are: Immunity from danger; simplicity of working; assistance to ventilation. The quantity of air given to aid ventilation, however, is very small as compared with the volume of air needed. In the use of compressed air there is no danger of sparking, or cables being cut, as in electric transmission lines.—*Engineering and Mining Journal.*

U. S. PATENTS
ESPECIALLY PREPARED FOR
COMPRESSED AIR

821,041. REPAIR-PLUG FOR PNEUMATIC TIRES. Ralph P. Kinney, Cleveland, Ohio. Filed Oct. 20, 1905. Serial No. 283,586.

821,299. AIR-COMPRESSOR AND THE LIKE. Alphonse J. Lavoie, Toronto, Canada. Filed March 2, 1905. Serial No. 248,075.



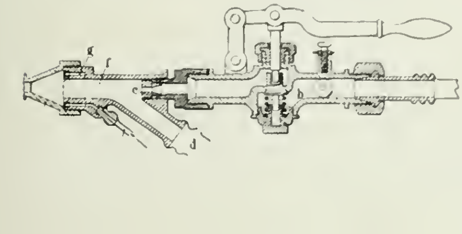
Claim.—1. In a device of the class described, in combination, a cylinder having an open end, an annularly-arranged outlet-port, a water-jacket surrounding said cylinder, and inlet and outlet passages at opposite sides of said water-jacket, said jacket having ingress and egress ports, a head, having a centrally-disposed boss closing said open end, an annular partition surrounding and forming with said boss an annular inlet-port to said cylinder, a vertically-disposed partition forming with the annular partition-chambers to register with said passages, and annular inlet and outlet valves mounted in said head as and for the purpose specified.

821,325. BEARING FOR ROCK-DRILLS. Thomas E. Adams, Cleveland, Ohio. Filed June 7, 1905. Serial No. 264,132.

821,399. HOISTING-CRANE. Milford F. Berry, Fay, N. Y. Filed Dec. 23, 1904. Serial No. 238,132.

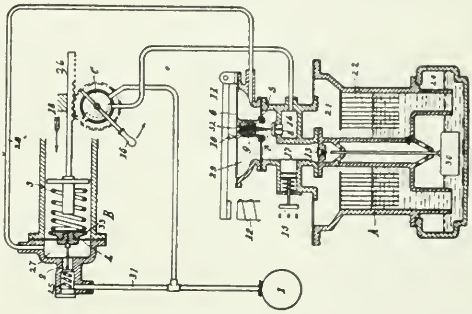
Claim.—In a crane, a mast having a lower pivot, an upper socket member secured to the mast, a pivot-rod extending within said socket member and provided with bifurcated arms, a support for receiving the ends of said arms, guiding-sheaves mounted on the bifurcated arms, a crane-arm also having guiding-sheaves, a hoisting-cable guided by the several sheaves, a stationary operating-cylinder, a piston disposed in said cylinder, a piston-rod, and means for connecting the cable to the piston-rod.

821,415. SAND-BLAST MACHINE. Charles A. P. Hess, Paris, France. Filed Feb. 10, 1904. Serial No. 192,928.



Claim.—1. In a sand-blasting machine, a mixing-chamber divided by a longitudinal partition into two compartments, a projecting nozzle secured to the chamber and provided with a partition in alinement with the partition of the chamber, and means for forcing air and sand into the compartments of said chamber.

821,418. AUTOMATICALLY-REGULATED LIQUID RHEOSTAT OPERATED BY MEANS OF COMPRESSED AIR. Coloman de Kando, Budapest, Austria-Hungary, assignor to Railway Electric Power Company, a Corporation of Maine. Filed Nov. 27, 1903. Serial No. 182,700.



Claim.—1. A liquid rheostat combined with a supply of compressed air, a throttle-valve between said compressed-air supply and said rheostat adapted to control the supply of compressed air to the rheostat; said valve being controlled by the combined action of the electric current flowing through said rheostat and compressed-air pressure.

821,524. PNEUMATIC CONCRETE STEEL CAR-BUMPER. Thomas McCormick, Somerville, Mass. Filed Dec. 11, 1905. Serial No. 291,353.

821,563. GAS-PUMP. Richard Whitaker, New Brunswick, N. J., assignor, by direct and mesne assignments, to Brunswick Refrigerating Company, a Corporation of New Jersey. Original application filed Jan. 11, 1904. Serial No. 188,612. Divided and this application filed Jan. 5, 1905. Serial No. 239,723.

821,568. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. Frederick W. Wood, Kansas City, Mo. Filed June 13, 1905. Serial No. 265,111.

821,574. FLUID-PRESSURE REGULATOR. Alexander Andrews, Carbondale, Ill. Filed Aug. 3, 1905. Serial No. 272,564.

821,584. PNEUMATIC STACKER AND STACKER ATTACHMENTS FOR THRESHING MACHINES. Samuel D. Felsing, Crookston, Minn., assignor to The Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Aug. 15, 1904. Serial No. 220,788.

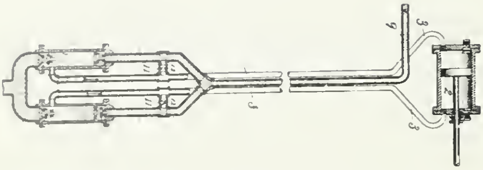
Claim.—1. In pneumatic stacker attachments for threshing-machines, the combination with the stacker-frame and with the fan, hopper and delivery-chute mounted thereon, of means for connecting the stacker-frame to threshers, said connecting means being adjustable in accordance with the different widths of the threshers, substantially as described.

821,663. FLUID-PRESSURE CYLINDER Thomas J. Mitchell, Connellsville, Pa. Filed Sept. 13, 1902. Serial No. 123,357.

821,672. AUTOMATIC CONTROLLER FOR MOTOR-COMPRESSORS. Walter J. Richards, Milwaukee, Wis. Filed March 9, 1904. Serial No. 107,317.

821,677. LIQUID-IMPELLING APPARTATUS. Danville W. Starrett, Oakland, Cal. Filed June 12, 1903. Renewed Nov. 20, 1905. Serial No. 288,273.

Claim.—In a liquid-impelling apparatus, a receiver, a check-valve admitting the liquid to the receiver, a liquid-discharge pipe from the receiver, a check-valve between them, a compressed-air pipe having separate communications with the receiver and with the liquid-



discharge pipe, and means for producing alternately positive and negative pressures in the compressed-air pipe, substantially as described.

821,706. ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. Filed May 14, 1903. Serial No. 157,067.

821,722. STRIKING-BAG OR OTHER FLUID-RECEPTACLE. Clarence A. Lindsay, New York, N. Y. Filed June 24, 1905. Serial No. 266,834.

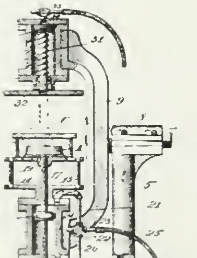
821,747. CONTROLLING APPARATUS. Walter J. Richards, Milwaukee, Wis. Filed July 2, 1903. Serial No. 164,085.

Claim.—In combination, an electric motor, a fluid-pump driven thereby, a pressure system supplied by said pump, switching means controlled by the pressure in said system to govern the circuit for said motor, and electrical means for preventing the operation of the suction-valve of said pump upon the closure of the circuit through said motor.

821,758. VALVE. Frank L. Smith, Chicago, Ill., assignor of two-thirds to Alva C. Ricksecker and one-third to Lewis A. Nichols, Chicago, Ill. Filed July 18, 1904. Serial No. 216,935.

821,776. MEANS FOR REMOVING DUST. Carl F. W. Zoeller, Altona-Ottensen, Germany, assignor to The Firm of Alfred Gutmann Actien Gesellschaft für Maschinenbau, Altona-Ottensen, Germany. Filed June 28, 1905. Serial No. 267,420.

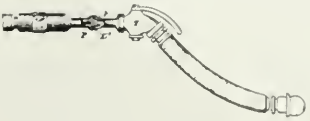
821,791. MOLDING-MACHINE. William M. Duncan, Alton, Ill. Filed March 13, 1905. Serial No. 249,886.



821,806. PNEUMATIC SURF-BOARD. Albert S. Johnston, Los Angeles, Cal. Filed May 19, 1905. Serial No. 261,206.

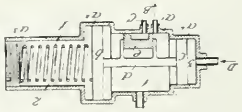
821,858. PNEUMATIC TIRE. Hans L. Christiansen, Boston, Mass., assignor of one-third to Harald Tidemand and one-third to Ole Worm Dahl, Boston, Mass. Filed May 24, 1905. Serial No. 261,933.

821,859. AUTOMATIC AIR-BRAKE CONTROLLER. Thomas Clegg, Winnipeg, Canada, assignor of one-third to Alexander McKinny and one-third to Robert Andrew Bonnar, Winnipeg, Canada. Filed Nov. 20, 1905. Serial No. 288,285.



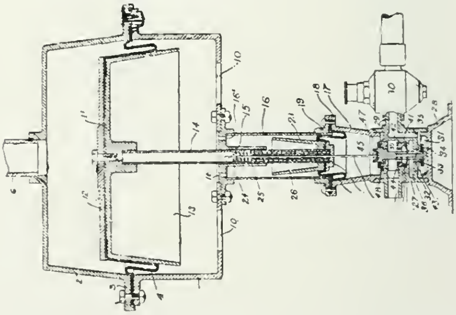
Claim.—In an automatic air-brake controller, a cylindrical casing having threaded ends and an intermediate contracted portion providing an interior annular shoulder, a valve-seat resting against said shoulder and having a beveled inner face, and a spring-pressed valve having a correspondingly-beveled edge and a by-pass, substantially as described.

821,870. REGULATOR FOR AIR-PUMPS. Wilhelm Hildebrand, Gross-Lichterfelde, near Berlin, Germany. Filed June 6, 1905. Serial No. 263,964.



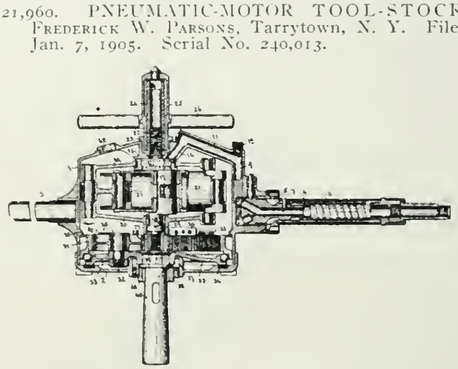
821,917. PNEUMATIC ACTION FOR PIANOS. Alfred Anderson, Chicago, Ill. Filed Aug. 24, 1904. Serial No. 221,941.

821,926. AIR-COMPRESSOR. Harry B. Cornish, Minneapolis, Minn., assignor of two-thirds to P. Peterson, Glenwood, Minn. Filed Feb. 2, 1905. Serial No. 243,799.



Claim.—The combination, with a casing having intake and exhaust ports arranged one above another and intake and exhaust valves, said intake-valve being normally open and said exhaust-valve closed, and said valves having a rod or stem, of a diaphragm within said casing above said valves and having an opening to receive said rod, means interposed between said diaphragm and the upper free end of said rod for raising said rod to close said intake-valve and open the exhaust, and a spring put under tension by the initial movement of said diaphragm to aid in seating said intake-valve, substantially as described.

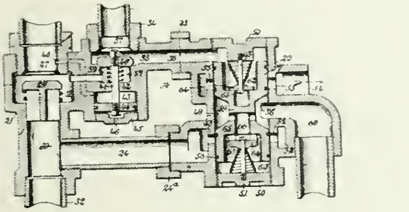
821,960. PNEUMATIC-MOTOR TOOL-STOCK. Frederick W. Parsons, Tarrytown, N. Y. Filed Jan. 7, 1905. Serial No. 240,013.



Claim.—In a pneumatic-motor tool-stock, the combination of a casing having a motor secured to one of its heads, admission and exhaust passages leading from the motor through the head and down the shell of the casing to a chambered boss formed thereon, a throttle-valve in said chamber, a sleeve through which air is admitted to the valve, said sleeve acting as one of the handles of the tool-stock, and means on said sleeve for shifting the valve to shut off or change the direction of flow through the said passages.

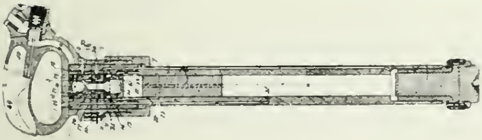
822,021. TIRE FOR VEHICLES AND THE PROCESS OF MAKING THE SAME. Thomas C. Sanderson, West New Brighton, N. Y. Filed July 14, 1905. Serial No. 269,574.

822,073. AIR-BRAKE SYSTEM. Arthur I. Perry, New York, N. Y. Filed May 26, 1905. Serial No. 262,363.



Claim.—In an air-brake system, the combination with a supply-pipe and a controlling-pipe, of a source of pressure connected with the supply-pipe, primary and secondary controlling-valves connected with the supply-pipe and controlling-pipe, said secondary controlling-valve comprising a piston-valve which may be simultaneously subjected to the influence of the pressure in the supply and controlling pipes and check-valves for closing the supply-pipe and controlling-pipe, and a brake-cylinder communicating with the secondary controlling-valve.

822,146. PNEUMATIC HAMMER. Edward C. Meissner, St. Louis, Mo., assignor, by mesne assignments, to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Nov. 12, 1900. Serial No. 36,212.



Claim.—A pneumatic hammer comprising a cylinder having ports for the admission and escape of air, a piston in said cylinder, and a valve for controlling the admission and release of air, said cylinder having a supplemental exhaust-port located in the forward portion thereof in position to be uncovered by the piston shortly after the initiation of its return movement and before the completion of such return movement, substantially as described.

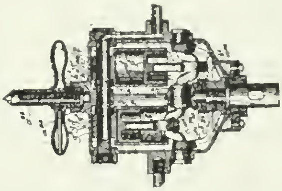
822,220. MACHINE FOR BLOWING HOLLOW GLASS ARTICLES. Cornelius J. Nolan, Toledo, Ohio. Filed Oct. 29, 1904. Serial No. 230,566.

Claim.—In a glass-blowing machine, the combination of an air-conduit leading to the article to be blown, of an air-valve in said conduit, and means for opening and closing the same to admit a limited quantity of air, and means for subsequently opening the valve for blowing purposes, for the purpose described.

822,223. AUTOMATIC CONTROLLER FOR PRESSURE SYSTEMS. Walter J. Richards, Milwaukee, Wis. Original application filed March 9, 1904. Serial No. 197,317. Divided and this application filed April 6, 1905. Serial No. 254,256.

822,367. PNEUMATIC DRILL. Adelbert P. Hanscom, Malden, Mass. Filed Aug. 27, 1903. Serial No. 170,893.

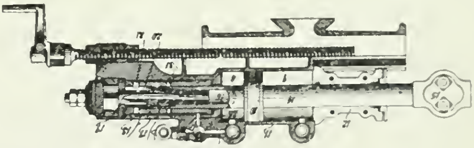
Claim.—In apparatus of the class described, a casing, an arbor rotatably mounted in and extended through one end thereof, a pair of oscillating cylinders each having a piston, a combined trunnion and valve structure supported within the casing and on which the cylinders are mounted side by side, at their ends, two separate crank-shafts operatively connected with the pistons and mounted in alinement, a pinion on each crank-shaft, and a gear operatively connected with the arbor and with which said pinions mesh at diametrically opposite points.



822,520. AIR-BRAKE. Ed A. Graves, Randolph, N. Y. Filed Feb. 8, 1906. Serial No. 300,193.

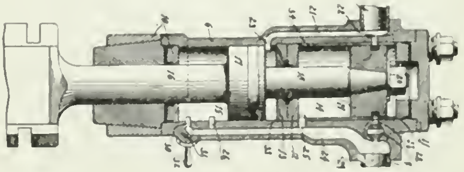
Claim.—The combination with train pipes or hose having coacting couplings upon their adjacent ends, of stop-cocks or valves arranged in said pipes, operating elements upon said valves, and a connection between one of said pipes and the operating element of the valve in the other, substantially as described.

822,596. ROCK-DRILL. Arthur H. Gibson, Easton, Pa., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Dec. 21, 1905. Serial No. 292,756.



Claim.—A tool-piston having a front rod and a tail-rod, a cylinder having a tail-rod chamber, pipes for feeding motive fluid alternately to the opposite sides of the piston and a single means for bringing the tail-rod chamber into open communication with one of said pipes or the atmosphere at pleasure.

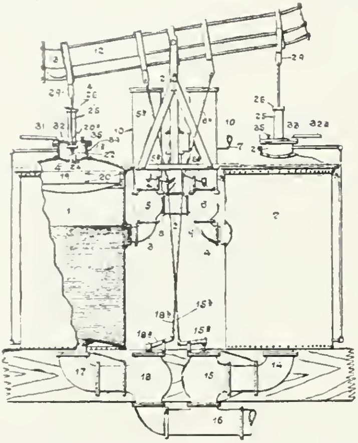
822,597. CHANNELING-MACHINE. Arthur H. Gibson, Easton, Pa., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Feb. 14, 1906. Serial No. 301,013.



Claim.—A tool-cylinder having piston-chambers therein, a piston having heads in said chambers, air-feeding tubes, said cylinder having front and back ports for the two chambers communicating with their respective tubes, and an auxiliary back port for one chamber communicating with the tube other than the one with which the other back port communicates and a valve for opening and closing said auxiliary back port.

822,645. AIR-GUN. Walter R. Benjamin, Granite City, Ill. Filed Aug. 24, 1905. Serial No. 275,582.

822,689. AIR-COMPRESSOR. Bryan Obear, St. Louis, Mo., assignor to Montague Compressed Air Company of Missouri, St. Louis, Mo., a Corporation of Missouri. Filed Nov. 28, 1904. Serial No. 234,615.



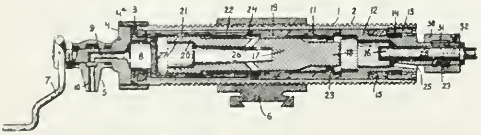
Claim.—The combination with a compression-tank and valve controlling the admission to and exhaust therefrom of the motive fluid, of a float in the tank, a piston connected to the controlling-valves, and a weighted valve in the path of movement of the float and arranged to first engage and initially lift the piston and afterward admit beneath the same compressed air from the tank; substantially as described.

822,747. AIR-BRAKE. George E. March, Muskegon Heights, Mich., assignor of one-half to Lawrence G. Sweningston, Muskegon, Mich. Filed April 20, 1905. Serial No. 256,573.

823,023. AIR-BRAKE APPARATUS. Henry F. Bickel, Plainfield, N. J., assignor to New York Air Brake Company, a Corporation of New Jersey. Filed Nov. 6, 1905. Serial No. 286,098.

Claim.—The combination with an automatic air-brake apparatus; of means responsive to flow of air into the train-pipe in the release operation for delaying the discharge of air from the brake-cylinder of one of the brake equipments, substantially as described.

823,048. AIR-BRAKE. John P. Kelly, Watertown, N. Y., assignor to New York Air Brake Company, a Corporation of New York. Filed Feb. 12, 1904. Serial No. 193,279.



823,059. ROCK-DRILL. Edward Leichter, Nevada City, Cal., assignor of one-fourth to John Bender, Hamilton, Ohio, and one-fourth to J. C. Campbell, Nevada City, Cal. Filed May 20, 1905. Serial No. 261,294.

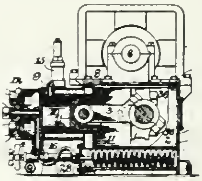
Claim.—In a rock-drill, the combination, substantially as set forth, of a shell, means for turning and advancing said shell, a cylinder within the shell, a fluid-actuated piston reciprocating within the cylinder, a chuck-body separably disposed within the forward end of the shell and having a chambered portion within the shell, and a bushing secured in the forward end of the shell and serving to retain the chuck-body therein.

823,060. COMPOUND FLUID-PRESSURE MOTOR. Joseph P. Magney and William H. Masterman, Los Angeles, Cal., Frederick R. Kellogg administrator of said Masterman, deceased, assignors to National Engine Company, Los Angeles, Cal., a Corporation of Arizona. Filed Aug. 1, 1905. Serial No. 272,162.

823,105. PRESSURE-ACTUATED VALVE-GEAR. William H. Collier, Jackson, Tenn. Filed March 31, 1904. Serial No. 201,023.

823,114. TRAIN SIGNALING SYSTEM. Joseph Gerard, Gainesville, Tex. Filed July 31, 1903. Serial No. 167,792.

823,156. FLUID-COMPRESSOR. Niels A. Christensen, Milwaukee, Wis. Original application filed Sept. 9, 1899. Serial No. 729,957. Divided and this application filed Dec. 11, 1899. Serial No. 739,900.

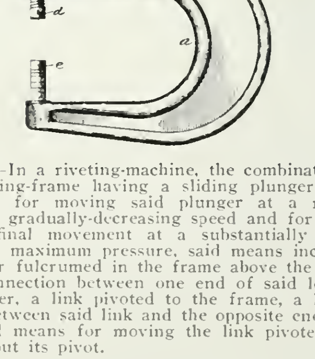


Claim.—A compressor comprising a casing, a plurality of cylinders therein having pistons, such casing having a false bottom forming a cooling-chamber integral with said casing and each of said cylinders having independent and valve-governed suction and discharge passages, a series of independently-removable covers for said chambers provided with passages for the inlet and exit of the fluid under pressure, and independent cooling-coils located in said cooling-chamber and connected at their ends with said passages in the removable covers.

823,185. AIR-VALVE FOR GAS-ENGINES. Reuben Miller, Jr., Pittsburg, Pa., assignor of one-half to D. W. Dunlevy, Pittsburg, Pa. Filed Jan. 27, 1905. Serial No. 242,945.

823,210. TURBINE-MOTOR. Nathan W. Fletcher, Chicago Heights, Ill., assignor to Turbine Motor Tool Company, Chicago, Ill., a Corporation of Illinois. Filed April 27, 1904. Serial No. 205,098.

823,273. FLUID-PRESSURE RIVETING-MACHINE. Elmer E. Hanna, Chicago, Ill. Filed May 15, 1903. Serial No. 157,234.

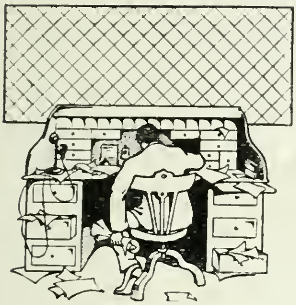


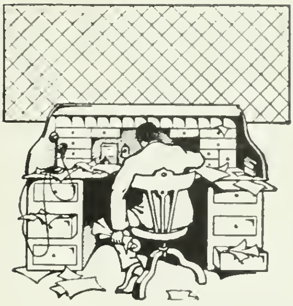
Claim.—In a riveting-machine, the combination with a supporting-frame having a sliding plunger therein, of means for moving said plunger at a relatively rapid and gradually-decreasing speed and for continuing the final movement at a substantially uniform speed and maximum pressure, said means including a main lever fulcrumed in the frame above the plunger, a link connection between one end of said lever and the plunger, a link pivoted to the frame, a link connection between said link and the opposite end of said lever, and means for moving the link pivoted to the frame about its pivot.

823,274. FLUID-PRESSURE RIVETING-MACHINE. Elmer E. Hanna, Chicago, Ill. Filed May 15, 1903. Renewed April 25, 1906. Serial No. 313,680.

823,278. PNEUMATIC ECONOMIZER AND AIR-INJECTOR. Edmund Hoxie, Everett, Mass. Filed Dec. 17, 1904. Serial No. 237,259.

Claim.—An air-injector, comprising a plurality of units arranged in tandem, means for passing air under pressure successively from one unit to the next in series and each unit of said series having also an independent connection with the air-supply for increasing the speed of the air already in motion, and an inwardly-opening check-valve for the unit or units beyond the first unit.





Office CHIT-CHAT

Compressed Air, New York.

Gentlemen:—I have the letter of your Mr. Hulbert and beg to thank you for the attention shown my recent inquiries. I have heard from two people already, and am very anxious to hear from Prof. Lucke.

FIRST COPY OF YOUR MAGAZINE RECEIVED AND I HAVE HAD MY MONEY'S WORTH IF I NEVER RECEIVE ANOTHER COPY.

I enclose list of some of our principal operators. Every one uses compressed air and should have your valuable magazine. Write them and send sample copy. Use my name if you wish.

Very truly yours,

——————, Pres.

The —— Mining and Development Co.

¶ When we receive letters such as this we naturally expand with a justifiable and joyful pride, and, to be quite truthful, we have been expanding very frequently of late.

¶ We realize, however, how dangerous it is to let expansion get the mastery, as a too rapid and overwhelming enlargement might very easily extend to the capital regions and cause plain swelling of the head.

¶ Which would mean such over-confidence in the worth and merit of COMPRESSED AIR that the reading pages would be allowed to deteriorate with a balancing booming of the advertising pages, a condition which would be equivalent to driving a team of horses and economizing by denying them oats and water.

¶ We refuse to be flattered out of our sense of proportion. We refuse to be stroked and patted so hard that we lose our balance. We do not mean for one moment that we don't enjoy being told how good the paper is—nor do we mean to imply that Mr. ——— letter is EMPTY flattery—the trouble that he has taken in giving us a long list of possible subscribers precludes the intimation—but we do mean that words of encouragement will be received, joyfully received and accepted with gratitude and used only as a spur to further us to better deeds.

¶ The advertising pages continue to show a healthy and material growth, and we may be partially excused for pointing a happy finger each month at the little table below, showing just how new advertising has come in. Since the May issue of COMPRESSED AIR the following concerns have put their O. K. on the magazine by stretching their appropriations in order to include us in their advertising plan:

Bury Compressor Co.	1/4 page
Peter A. Frasse & Co.	1/4 page
Hanna Engineering Works	1/4 page
Sprague Electric Co.	1/2 page
Traylor Engineering Co.	1 page
Sargent Steam Meter Co.	1/4 page
A. E. Hoermann	1/4 page
Wm. Powell Co.	1/8 page
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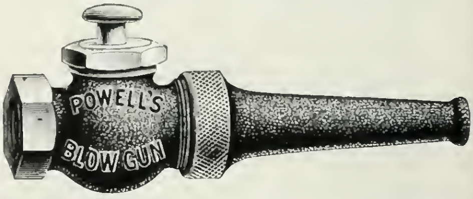

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COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

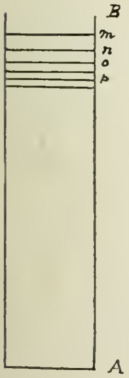
SEPTEMBER, 1906.

VARIATION IN ATMOSPHERIC PRESSURE WITH ALTITUDE.

Written for Compressed Air by D. W. Hering.

In practice, a reference to standard tables often suffices for the engineer at least for approximate values of quantities, and too often a first approximation is as near the truth as he tries to get, but a table at best gives quantities that depend upon some one or more fundamental conditions, and is correct only for those conditions. An expert should know how to derive the table itself or the formula from which it is computed, and how to vary the table with varying initial conditions.

To determine the variation in atmospheric pressure with varying elevation:



Let AB represent a prism of air, 1 sq. ft. in area of cross section.

Let P_a, D_a represent the pressure and density, respectively, of air at the base of the column.

Let P, D represent pressure and density respectively at any point, m.

Let h represent the height of m above A.

Conceive the prism to be made up of successive very thin layers, as mn, no, op, etc., of equal weight w, and of variable height dh. For a given temperature, the pressure at any point is proportional to the density; or,

$$\frac{P_a}{P} = \frac{D_a}{D}, \quad \text{therefore}$$

$$\frac{1}{D} = \frac{P_a}{P}\,\frac{1}{D_a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(A)$$

For any stratum of depth dh, the density is S, the volume in cubic feet is the area multiplied by the height, or $1 \times 1 \times dh$, and the weight is the increment of pressure; or $w = dP$. If w is pounds, the mass of one stratum is $\frac{w}{g}$, and the density being the ratio of mass to volume,

$$D = \frac{w}{g} \Big/ (1 \times 1 \times dh) \quad \text{whence}$$

$$dh = \frac{w}{g}\,\frac{1}{D} \quad \ldots\ldots\ \ldots\ldots\ldots\ldots\ldots(B)$$

Substituting for w its value dP and for $\frac{1}{S}$ its value from (A) we have

$$dh = \frac{P_a}{D_a g}\cdot\frac{dP}{P} \quad \ldots\ldots\ldots\ldots\ \ldots\ldots(C)$$

$$\text{Integrating } h = \frac{P_a}{D_a g}\int_P^{P_a}\frac{dP}{P} = \frac{P_a}{D_a g}\,\mathrm{Log}\,\frac{P_a}{P}$$

$$\text{or} \quad h = 2.303\,\frac{P_a}{D_a g}\,\mathrm{Log}_{10}\,\frac{P_a}{P} \quad \ldots\ldots\ldots\ldots(D)$$

For uniform temperature throughout the column, the factor $2.303\,\frac{P_a}{D_a g}$ is constant within the limits of height for which g may be taken as constant. Since the Pressure P_a here is in absolute units, $\frac{P_a}{g}$ is pounds, and by placing for $\frac{P_a}{g}$ the pressure in pounds per square foot, and for $\frac{1}{D_a}$ the volume in cubic feet per pound, then for a temperature of 32° F and under standard barometric pressure

$$\frac{P_a}{D_a g} = 26214$$

and equation (D) gives

$$h = 60360\,\mathrm{Log}_{10}\,\frac{P_a}{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots(E)$$

This equation gives the relation between the pressure, P, and the corresponding elevation, h, provided the air is at a temperature of 32° F. throughout. The ratio $\frac{P_a}{P}$ is equal to the relative barometer heights at the foot and at the top of the column of air, reduced to standard temperature in each case, but the height of the column to produce either pressure will vary with the temperature of the air. The column may be assumed to have throughout a temperature which is the mean of that at the top and that at the bottom and, if this be called t° F, the height of the column will be the above value of h multiplied by $\frac{461 + t°}{493}$ or finally, calling the difference of elevation in feet between two points H,

$$H = 60360 \frac{461 + t}{493} \text{Log}_{10} \frac{P_a}{P} \quad \ldots\ldots\ldots(F)$$

From this formula, for any pressure P_a at a given station, and mean temperature t° of air column, the height H may be computed to correspond to a pressure P, or conversely the pressure P that would be found at a height H.

NOTE.—In strict accuracy the absolute pressures Pa and P, whether expressed in pounds weight, or in height of column of mercury, will depend for their numerical value upon the value of g; and this depends on both the latitude of the place and elevation above sea level. Assuming Pa to be the pressure for sea level at 45° represented by a certain height of mercury column, for the correct pressure elsewhere the barometer height would have to be multiplied by $(1 - 0.0026 \cos 2 L = 0.0000006 h)$ in which L is the latitude and h is the altitude in feet; this factor is so near unity as to be negligible. For example, at the Equator, at the height of 20,000 feet the factor is .9962; at the Pole, at sea level, it is 1,0026; the total variation therefore between these extremes is the difference of these quantities, or .0064; that is less than two-thirds of one per cent.

If in equation (F) we take P_a as 14.7 lbs per square inch as at sea level, and assume for the mean temperature t, 50° F., the formula gives

$$\log 14.7 - \text{Log } P = \frac{493 H}{511 \times 60360}$$

$$\text{or} \quad \log P = 1.167317 - .000016 H \quad \ldots\ldots(G)$$

In which P is absolute (not gauge) pressure in pounds per square inch, and H is feet. This is probably as simple a form as the equation can be put into. By assigning values to H and computing P the second column of Table 1 was obtained.

The third and fourth columns were obtained from equation (F) in the same manner by putting 35° and 20° instead of 50° for t. These can be represented by curves, but it is readily seen that a different curve is required for each temperature. The accompanying diagram shows the curves for 50° and 20°.

An empirical formula given by William Cox in COMPRESSED AIR for October, 1897, is

$$\left.\begin{array}{l}\text{``Atmospheric pressure,}\\ \text{A, at any elevation}\end{array}\right\} = 14.72 - \frac{57000 - N_2}{100\,000\,000}$$

where N is the elevation in feet at which the pressure A is sought" and A is pounds per square inch. This does not take account of temperature but gives values agreeing pretty closely with those computed above for 35° F

Elevation in feet.	PRESSURE IN POUNDS PER SQUARE INCH Mean Temp. t = 50°	t = 35° F.	t = 20° F.
0 feet	14.7	14.7	14.7
1000	14.17	14.15	14.14
2000	13.66	13.63	13.59
3000	13.16	13.12	13.07
4000	12.69	12.63	12.57
5000	12.23	12.16	12.09
5280	12.1	12.03	11.96
6000	11.78	11.71	11.63
7000	11.36	11.27	11.18
8000	10.95	10.85	10.75
9000	10.55	10.45	10.33
10000	10.17	10.06	9.94
12500	9.28	9.15	9.02
15000	8.46	8.32	8.18
3½ miles	7.44	7.30	7.14

TABLE 1.

A mean temperature of, say 50°, might mean 90° at the sea and 10° at the top, or it might mean 60° at sea level and 40° at the top. It is plain that the height of air corresponding to this mean temperature and therefore the height through which the tabular values for that temperature could apply would be much less in the latter case than in the former. For a given temperature at sea level the mean temperature for a column 1,000 feet high will be different from that for a column 10,000 feet high, so that a table based upon a given mean temperature will be correct only up to a height depending on the temperature at the base, or up to a prescribed height only for a proper temperature at the base.

Not only does the temperature fall as the elevation increases, but the rate at which it falls is not uniform; that is, it decreases more in the first thousand feet than in the second, and more in the second than in the third, and so on. A table, then, even if made out for numerous mean temperatures and a great variety of elevations, cannot be used intelligently without knowing how to select the proper temperature column of the table. It is obvious that a list of pressures correct for a mean temperature of, say 50°, could not be applicable at all when the temperature at the lower level is 50° or less.

A good general formula for changes of temperature with elevation may be obtained by reference to the snow line; i. e., the line below which all the snow is melted in midsummer. The elevation of this line, in general, between latitude 35° N, and 45° S, ranges from 12,000 to 18,000 feet above sea level. A suitable form of equation for the change of temperature is

$$T = T_o e^{-\frac{H}{h}} \ldots\ldots\ldots\ldots\ldots (H)$$

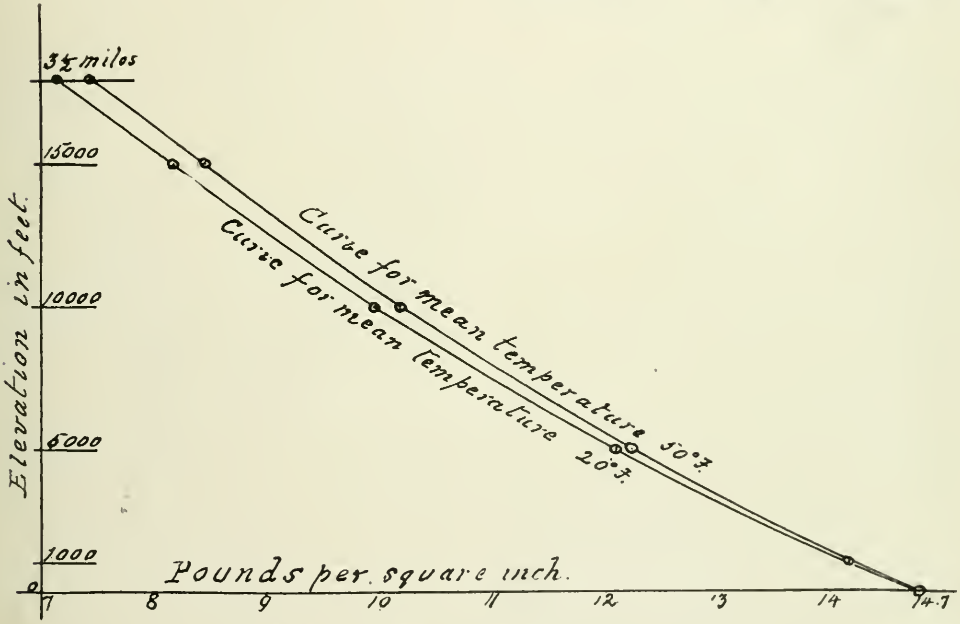
where H is any elevation above sea level, e the base of Naperian logarithms, T the temperature (absolute) at elevation H and T_o the temperature at sea level. If we take $T_o = 80°$ F., (541° absolute) as mean sea level summer temperature to go with H = 16,000 feet as snow limit, for which T = 32°, (493° absolute), the formula reads $493 = 541 e^{-\frac{16000}{h}}$ whence h = 172200. This makes the equation

$$T = T_o e^{-\frac{H}{172200}} \quad \ldots\ldots\ldots \quad (J)$$

From this equation, by giving T_o any value for the temperature at the lower level, the corresponding value of T for the height H may be determined, and therefore the proper mean temperature to use for a height H in the above table.

Suppose, for example, T° = 60° F., and we wished to reckon on a mean temperature of 50° as in the second column of the table. Through what range of elevation, H, would this extend? Since the lower temperature is 60° and the mean is 50° the upper temperature T must be 40° (501° absolute). Substituting these values in equation (J) we find H = 6,740 ft.

If, however, we wanted to know what changes of pressure to allow for through a height of 12,000 ft., with the mean temperature at sea level 60° F., these values in equation (J) give T=486° abs.=25° F., as the upper limit of temperature. This makes the mean temperature $\frac{60 + 25}{2} = 42°.5$ F., and the proper pressures could only be had from a table or a curve for this temperature.



CURVES SHOWING VARIATION OF PRESSURE WITH VARYING ELEVATINO.

Equation (J) leads to an interesting table of temperature-change from various sea level temperatures.

At Sea level	At 2500 ft.	At 5000 ft.	At 10000 ft.
32° F	25°.9	17°.9	4°.2
50°	42°.6	35°.4	21°.2
80°	72°.2	64°.5	49°.5
100°	91°.9	83°.9	68°.4

Table showing temperature at various heights, for different initial temperatures at sea level.

In applying equation (G) to a depth below sea level, H is a negative quantity, and log P is thus increased. For a mean temperature of 50°, as before, if H equals a depth of 2,000 feet, log $P = 1.199317$, whence $P = 15.82$ lbs. per sq. in. The pressure through this depth increases at very nearly a uniform rate with the depth $\frac{1.12}{14.7 \times 2000}$ part per foot. That is, the increase of pressure, and therefore of density, *for constant temperature* is .0000381 times the pressure at sea level for every foot of depth.

It is observed, however, that in general the temperature within the earth rises 1° F. for about every 60 ft. of depth. Since, for every degree rise of temperature under a given pressure the air expands, and therefore decreases in density by $\frac{1}{461 + t}$, this would tend to counteract the increase of density in descending into the earth, and in very nearly the same proportion as it would increase by reason of pressure; for if, as in the above example, the temperature at the surface is 50° F., then the density diminishes $\frac{1}{511 \times 60}$ part, or .0000326 per foot of depth by reason of rise in temperature. With air at 32° at sea level the proportional changes in density per foot of depth are.

Increase on account of pressure, .0000396.

Decrease on account of temperature, .0000338

These so nearly counteract each other that the actual change of density is only .000006 per foot of depth. Between surface temperatures of 20° and 80° this may be taken as an average fractional change in density per foot descent. An increase of .5 pound per square inch would be an increase of $\frac{.5}{14.7}$, or .034016, to effect which at the rate of .000006 per foot would require a depth of $\frac{.034016}{.000006}$, or 5 670 feet, or over one mile.

The effect of altitude on the efficiency of compressors may be briefly stated. If air at standard pressure of 14.7 pounds per sq. in., is compressed to G pounds per sq. in. gauge, its pressure is then $G + 14.7$, and when cooled to the initial temperature under this pressure, the volume will be $\frac{14.7}{G + 14.7}$ part of the volume of free air taken in by the compressor. If, by reason of elevation or other cause, the air initially is at a pressure of p pounds per square inch, and is compressed to the same gauge pressure, G, as before, then when cooled to the initial temperature its volume will $= \frac{p}{G + P}$ part of the volume of free air taken in by the compressor. For the same number of strokes this volume of free air will be alike in both instances; therefore the efficiency of the compressor working at an elevation as compared with its work at standard pressure will be the ratio of the volumes after compression, provided the air is at the same initial temperature in both cases. That is,

$$\text{Efficiency} = \frac{p}{G + p} \div \frac{14.7}{G + 14.7}$$

It must be remembered, however, that the gauge itself, on which the pressures are indicated, must read zero under the pressure of the atmosphere wherever it is used. If it does not its readings must be corrected for this error, for p and $G + p$ stand for absolute pressures of the air before and after compression.

It is unnecessary to discuss this portion of the subject further here as it has been fully presented in COMPRESSED AIR; also in articles by William Cox, W. L. Saunders and F. C. Weber, in COMPRESSED AIR INFORMATION, pp. 98 to 105.

USES OF COMPRESSED AIR IN COAL MINES.*

By J. L. Dixon, E. M.

The subject of this paper embraces a wide field which cannot be fully covered in an article of this kind, but as the majority of the members of this institute are acquainted with the ordinary applications of this power in coal mines, it will only be necessary to make a brief resume of this part of our subject, leaving the less known and proposed applications of compressed air for more extended discussion.

The production of coal is one of the most important industries of the world both in point of material value and in the part it plays in our modern civilization. I need not say that without it the wonderful achievements of the past century would not have been possible and the present enormous industrial activity impossible; coal is indeed "king" and apart from the soil is the most valuable material asset of this great country, but this like most things of value can only be won by toil, by courage, skill and perseverance, and the world owes a debt of gratitude to those brave men who have spent their lives in ceaseless endeavor to render this toilsome and perilous occupation less arduous and less dangerous.

The harnessing of natural forces to the direct production of coal came tardily, but once fairly commenced made rapid strides until now the machine mine is the rule and not the exception as it was a comparatively short time ago. In a few years 80 per cent. of all bituminous coal in this country will be produced by mechanical means, the motive power being compressed air and electricity; the former has no conflict with the latter, for there is a wide field of usefulness for both. We do propose to show, however, that the latter is an ideal power for underground work and is supreme in that province.

---

*A paper presented to the Mining Institute at Pittsburgh.

In the installation of compressed air plants at coal mines it has been and is still to a great extent the custom to install the cheapest class of machinery, boilers of low pressure, compressors of low efficiency, and pipe lines at haphazard, in many cases

SO WOEFULLY INEFFICIENT

as to render the whole installation practically useless. This power has been condemned by some mining men who have had experience with or who have visited plants of this kind without taking the trouble to go deeper into the matter. There has, however, been a radical departure from these lines in the last few years; in that time many large coal companies have installed plants where both boilers and compressors are of the most refined type and the fuel cost of production has been decreased over 100 per cent. A plant of this kind with ample pipe lines will show at the distant working face a favorable comparison of cost per unit of power with any plant of any kind ever installed.

The uses of compressed air in coal mining are as follows:

Haulage, by locomotives and by stationary engines.

Coal cutting and drilling, by percussive and rotary machines.

Pumping (as we have had an able paper on pumping, we will omit it from this).

Shearing in entries and rooms.

Proposed method of saving life, by and with compressed air.

Haulage, by compressed air, is the latest practical method which has been introduced into mines and is one which possesses many and peculiar advantages, amongst them being the following: Its almost absolute reliability and nearly total absence of repairs, its flexibility and safety under all conditions. That these are valuable features, none will deny.

It is not the intention to enter into a detailed description of a compressed air haulage plant. I will only outline the system and will quote from an article on this subject which I wrote some time ago:

"A compressed air haulage plant consists of a three or four-stage air compressor, capable of compressing air to 1,000 pounds pressure per square inch, locomotives of suitable weight and power, and constructed

TO CARRY STORED-UP ENERGY

in the shape of compressed air sufficient for requirements, suitable charging stations, a stationary reservoir ,which may be a pipe line, where long or diverging runs exist, or one or more storage tanks where the runs are short, the air being compressed in this storage system while the motor is making its trip, admitting of a small steady running compressor.

"The general mechanism of an air locomotive, cylinders, valve motion, frame, wheels, etc., is similar to the steam locomotive except that bearings are larger and every detail of construction stronger. The main points of difference are that, instead of the usual boiler and water accessories for developing steam power, the air locomotive is equipped with one or more strongly constructed storage tanks which are charged with compressed air to a high pressure, usually from 700 to 1,000 pounds per square inch, sometimes to 2,000 pounds. A combination regulator and automatic stop valve leading to the auxiliary low pressure reservoir in which the air is carried at a uniform working pressure usually 140 pounds, though greater pressures are available for emergencies. Relief valves make it impossible to charge the motor tanks to an unsafe or higher pressure than required, the initial storage pressure decreases while the locomotive is working, so there is never any risk from over-pressure, the dangers incident to the operation of a steam locomotive boiler, such as excess pressure, burnt crown sheets, fire boxes or flues collapsed from low water are entirely eliminated in the operation of a compressed air motor as the boiler and its accessories, which are the chief items of repairs and elements of danger, are replaced by air tanks which are practically indestructible.

"The locomotives are charged at stations located on the main line, the time consumed in charging including coupling and uncoupling being from one to two minutes. These locomotives are made to order, and

TO SUIT THE CONDITIONS

of the haulage, long, short, wide, narrow and low, to suit conditions.

"There are a dozen or more compressed air haulage plants in successful operation in Western Pennsylvania and a large number in the anthracite mines, any of which to those interested would well repay a visit."

If desirable, animal power can with this system of haulage be entirely eliminated, small motors of from three to four tons being used in the rooms; these can be run on either iron or wood rails, iron of course, being preferable.

Regarding the economy of this system, there can no longer be any doubt it has been a success in this and every other respect ever since its inception. Take, for instance, the very first plant introduced into the anthracite region in 1895, according to a report of the chief engineer of the company, the cost per ton mile, net weight, was 1.91 per ton, this figure being obtained by dividing the total operation expenses for two years, including fuel, labor, repairs, interest and depreciation, by the product obtained by multiplying the number of tons hauled by the motors during that time, by the average distance it was hauled in miles or fractions of miles. The difference of cost in favor of compressed air as compared with mule haulage equaled the total cost of installation in 361 working days.

When it is taken into consideration that the plant was not worked much more than half of its capacity and that it was installed eleven years ago and paid for itself in so short a time, there can be no question as to its efficiency. Of course, the cost would differ with differing conditions; in some cases it would be higher and in many cases less. To sum up, it is a safe, flexible efficient,

RELIABLE AND ECONOMIC SYSTEM

of haulage, well worth your careful investigation.

Where the main haulage is rope, in some cases where animal power alone is relied on, stationary engines operated with compressed air are often used; for hauling coal out of dip entries or for hauling empty cars up any steep grades, the engines can be moved from place to place as occasion demands, and are very handy and useful where local dips abound.

Compressed air is playing a most important part in the mechanical production of coal, both percussive and rotary machines being driven by it. The puncher is the oldest and best known machine now in use, and in numbers far exceeds all other types combined; it is of exceedingly simple and durable construction, needing but few and inexpensive repairs. It is also a machine of wide adaptation and so flexible that it can be used under almost all conditions met with in coal mines. It has been in use for about twenty years during which time improvements have followed improvements until the pick machine of to-day is in simplicity, durability and cutting capacity almost as perfect as human skill can make it. It makes an undercut similar to that made by hand, which admits of easy blasting permitting the coal to roll forward, thus placing it in an ideal condition for loading, instead of merely dropping it an inch or so from the roof, as is the case with other machines. It cuts on the floor and does not leave three or four inches to be taken up by hand as the chain machine does. It can be used safely in bad roof where it would be extremely dangerous to use any other type. It can also be used to extract pillars, the chief necessity in this being the consent and concurrence of the mine boss. I have seen it used successfully in extremely bad roof for this purpose, and am sure it can be utilized in this work very much more than it is at the present time, if superintendents and foremen care to take the trouble of giving it their personal attention.

As most mining men are acquainted with the very simple mechanism and modus operandi of the puncher, it

WOULD BE WASTE OF TIME

to enter into a detailed description of either, so I will only say that this machine is for all around mining work, the simplest, cheapest, most durable, most flexible and most effective machine ever built. It is to-day producing seven-tenths of all machine mined coal in this country, and it will not only maintain this supremacy but join in the race, for it will be more than any other, better adapted to inevitable conditions which will prevail in the mining of the future.

The chain machine which is generally operated by electricity is also driven by compressed air, where conditions are suitable, that is to say, where the roof is good and the floor is level, and where the coal is free from sulphur balls, this machine does remarkably good work. The objections to it are mainly its bulk and weight, making the work of moving it around in the constricted mine space, extremely slow and laborious, its length making it necessary to leave an unpropped space of from 12 to 14 feet between the face and pole, the fact that it cuts above the floor and that the cut which is narrow and slot-like does not permit of effective blasting, or makes it imperative to blast so hard that the coal is much shattered. However, there are places where conditions are such that these objections are offset by the rapid cutting done by this machine, for in this respect it is superior to the percussive machine.

The principal point I wish to emphasize in this connection is that with compressed air either the percussive or rotary machine can be used, and as there are places in every mine where it is both desirable and profitable to use punching machines, that power which admits of the use of both now nearly approaches the practically ideal. This also holds true in the matter of drills and drilling for the percussive rock drill so indispensable in driving rock headings can only be operated by compressed air.

Considerable attention is now being paid to the perfection of a light, simple, portable rotary drill for drilling coal, slate and fire clay in mines. This seems to have been accomplished by a well known firm, in the shape of a machine which is a breast auger weighing 18 pounds and operated by compressed air. This is portable in the true sense and can be easily carried and operated by one man. I hope to see the time when these machines in the hands of experienced men will do all the drilling in our coal mines to the absolute

EXCLUSION OF DANGEROUS DRILLING

by inexperienced men, but of this, more hereafter.

Recently a machine of a new type has been perfected and placed on the market; many are in successful use where the conditions preclude the use of any other machine.

It is to all intents and purposes a long stroke rock drill mounted on a column, the mounting being specially adapted for coal mining work. The column may be of any length from two to eight feet. It is placed at right angles to the roof and floor about 3½ feet from the face and six feet from the rib in undermining or ten inches for shearing; it has a rosette on one end and a heavy jack screw in the other terminating in a rosette foot piece; a substantial block of wood is placed under the foot piece of the column and a piece of hard wood about 2 inches thick is placed on top, the jack screw is then screwed as tight as possible. This operation need not consume more than five minutes, it is then ready for work. With one set up an undercut can be put in, in any part of the seam, 12 feet wide and any depth up to 8 feet, the average height of cut being 3 inches. This machine can be used and is used profitably in pitching veins, where the pitch is so great as to entirely preclude the use of any other machine. It is, of all machines of the percussive type, the easiest to run, there being absolutely no jar on the runner, his function being to guide the pick or bit and place the blows where they will do the most good.

I wish particularly to call your attention to this machine because of its efficiency in shearing and because the importance of shearing in coal mining has practically been lost sight of. Hitherto, there has not been any satisfactory mechanical means of doing this work, which may account in a measure for its almost utter lack in modern coal getting. I remember that when as a boy I worked in the English mines, no one was allowed to fire a shot in either entries or rooms without one rib being sheared. I remember also that my father worked at this one group of mines for nearly 40 years, part of the time as manager and there never was an explosion by blown out shots or otherwise, and some of the mines were very gaseous; had the same reckless, ignorant methods of blasting from the "face" which obtain here, been used there, the mining population would have been from time to time considerably

THINNED BY EXPLOSIONS

from blown-out shots. Explosions from this cause are multiplying with alarming rapidity and no remedy is being applied. There stands a monument not far from Pittsburgh but recently dedicated to the memory of 178 victims of a blown-out shot, the mine where this dreadful holocaust occurred is again at work, the same methods of blasting obtain as before, the same ignorant element handles the dangerous agent which together with dust and gas sent their predecessors to their narrow cells and long home. In a word all the elements and agencies necessary for a repetition of the awful disaster are potentially present, and as if this were not enough they are about to install that subtile power electricity, so dangerous in a gaseous mine, but there is no protest, no remedy suggested, yet the remedy is very obvious. There is nothing mysterious about a blown-out shot, it is simply a manifestation of carelessness or ignorance or both. The remedy, which should be enforced by law, and which would prove most effective, would be the absolute prohibition of any shot firing by any but approved and competent men and the enactment of a law compelling the shearing of both room and entries before blasting. The introduction of mining machinery has made quite feasible the employment of skilled men to do all the drilling and blasting most of which can be done at night, thus exposing fewer men to danger and rendering the mine safer and more sanitary during the day.

There will be, I have no doubt, many objections to a drastic measure of this kind and one of the objections will be that it will increase the cost of coal. That indeed would be a serious obstacle; there could be no greater in this age of selfishness and greed, which sacrifices human health and even life in its mad race for wealth.

The labor for drilling and blasting would average about one cent per ton, varying with conditions, shearing, because of the decrease in amount of slack and nut and shattered coal, would pay for itself and a

HANDSOME PROFIT WOULD ACCRUE

to the operator by the absence of blown-out shot disasters and by the approbation of his conscience for the establishment of a humanitarian regulation which does not cost him anything.

I think a question of this kind is worthy the attention of this body of representative mining men. It is your solemn and sacred duty to safeguard the lives placed under your care and you cannot contemplate without dire foreboding the ignorance and consequent recklessness of the modern mine crew. There is no other place or no industry on earth where the methods which obtain in some of our mines would be tolerated for an instant. In every industry where explosives are used except in coal mining, only experienced men appointed for that purpose are permitted to handle them, but in coal mines where the danger can hardly be overestimated or exaggerated and where the safety of all depends upon the skill and care of each one, men whose ignorance is monumental, are allowed to drill holes as they please, charge them as they please and fire them at their own pleasure. This is no figure of speech. I remember visiting a mine in company with the manager. The mine, which was in the first stages of development, was generating considerable gas; while in one of the entries, I noticed a polyandrous Slav ram a cartridge of such astounding proportions into a drill hole that I asked the manager as a special favor to allow me to get out of the shaft before the shot was fired, and incidentally suggested that he take all the rest out except the Slav. He laughed and said, "There is no danger." On arriving at the surface, I tried to convince him that there was very grave danger, but of course, he knew better. A few weeks after there was an explosion in this mine from a blown-out shot. Over a dozen men were killed. I regret to say that the name of the manager did not appear in the list.

While I have suggested a remedy for one of the most frequent causes of explosions, I wish also to suggest a method for the preservation of life after explosions in which compressed air is vitally essential, for after

HUMAN FORESIGHT AND SKILL

has exhausted every method and taken every precaution, it is safe to infer that explosions will still occur, for it seems as if there are causes mysterious and unknown, which set at defiance all human foresight and the deadly explosion takes place with all its attendant horrors.

In most explosions, the majority of those lost are asphyxiated by the after-damp. In numerous cases they have sufficient time to travel considerable distance before being overtaken and overcome by the deadly gas; in very many cases, men have lived for hours but at last their prison house becomes entirely devoid of life-giving oxygen, and they fall into that last sleep which knows no awakening. Had there been some definite point to which these men could have directed their steps where fresh air and food in abundance could be found, it is likely that the death list would have been diminished. It is singular that in most towns effective arrangements are made for the protection of life from fire, while all along the coast lines both of ocean and lakes, life-saving stations are established for the protection of the lives of those who go down to the sea in ships, yet nothing has been done for the preservation of the lives of those who work in perpetual danger and may at any hour be imprisoned deep down in the bowels of the earth.

The plan I wish to suggest is that in every mine, life saving stations or chambers of refuge should be established. They should be excavated in the solid coal, the approach should be by a long narrow entrance which could easily be rendered explosion proof. The chambers should be about 15 feet by 30 feet and should be connected with the surface by a compressed air line, which should be put down a bore hole directly into the chamber, or should be laid in the mine in such a way that

NO EXPLOSION WOULD DISTURB

it. This should be done by laying it in a ditch made for that purpose, or by covering it in such a manner that the line would not be broken by falls of rock. Connections should be made from this pipe into each chamber of refuge, which when turned on would give a sufficient supply of air to any refugees who may be so fortunate as to reach them. These chambers should be amply provided with first aids to the injured, with restoratives, with condensed foods, all in damp-proof cases. They should also be supplied with electric safety lamps, flasks of oxygen and with modern life saving appliances so that the safety chamber could be used as a base from which rescuers could go forth to the aid of those unable to reach the station. These places should also be connected with the surface by an explosion proof telephone system. This can be done by laying the wire in the compressed air pipe. It seems strange that while this remarkable invention is being used in nearly every artery of human industry, it should have been used so little in our coal mines. I will venture to say that there is not one explosion proof telephone system in any mine in the United States. How invaluable this would be to the imprisoned below and to those frantic with grief above, I need not say; just imagine what a blessing it would have been to many of the men entrapped in that large, French mine where over 1,300 were lost, making it the most disastrous accident in all mining history. There is evidence that hundreds of these men lived for days, some of them for over two weeks, even then still alive, living on the bark of props and on putrid horse flesh. When one reads of their awful sufferings, the heart turns sick with horror of it all. Had this mine been adequately supplied with safety chambers connected with the surface by compressed air and telephone, it is possible that hundreds would have been saved. They could have made their condition known to those above and a plentiful supply of cool, fresh air and of liquid food could have been transmitted to them, no matter how far away in the interior of the workings, they might have been.

A system of this kind would

NOT BE EXPENSIVE TO INSTALL

and would be inexpensive to keep in order and in readiness for any emergency. In mines where compressed air is used, it could, by making the line explosion proof, be made part of the regular working system. A six or eight inch main line would insure a good supply of air for from two to three hundred men if confined to three or four safety chambers. The line can also be used for the transmission of liquid foods, as well as a conduit for telephone wires.

In order that the miners should have a guide to the safety station, arrows pointing in its direction should be made on the side of the entries with luminous paint, beacons pointing the way to present safety and eventually to wife, home and sunshine. Full instructions in every language represented in the mine should be printed and posted in conspicuous places. These instructions should fully set forth the uses of the system and under what conditions it is to be used. At each large mine, there should be a corps of trained men conversant with methods of life saving after an explosion, who could act with intelligent and efficient promptness. Let it be said to the deathless honor of coal miners everywhere that in case of an explosion, there are always volunteers ready to rush into the very jaws of death, and the history of coal mining is replete with deeds of the loftiest heroism before which the boasted exploits of chivalry pale into insignificance. Again and again rescue parties have descended into the yawning blackness of the pit, have met death in the noblest endeavor to save their comrades, often, I am sorry to say, acting

WITH MORE BRAVERY THAN JUDGMENT,

unnecessarily and unavailingly sacrificing their valuable lives. We should be prepared for explosions in our mines as we are prepared for fires in our cities, for no man knoweth the day or the hour when these terrible disasters will send a thrill of horror throughout the world. The future of mining is fraught with grave dangers, each year our already enormous output will be increased; each year will mean more shafts, more gaseous mines, and unless more precautions are used, each year will add to our already too long list of disasters.

The conservative, thoughtful mining man cannot but view with alarm the manifest recklessness of many operators in introducing electricity into mines generating gas in dangerous quantities, thus increasing a danger which at the best is perilous enough. Compressed air is an ideal power under all conditions; it is efficient, economical, healthful and it is never a menace to valuable property, and still more valuable lives. It lessens the danger of explosions and in the event of one occurring, will be, if used as indicated, a very present help in time of trouble.

THE LATEST COMPRESSED AIR ENGINE.

The American Machinist, in a recent issue, gives an account, with the accompanying illustrations, of the *smallest* steam engine. It can hardly be called a steam engine as it would not be practical to run it by steam and it is actually run by compressed air. As will be seen in Fig 2, it is an oscillating engine of simple design. The cylinder is .03 inch in diameter by .03125 inch stroke, and with 30 pounds air pressure and an assumed mean effective pressure of 20 pounds at the normal speed of 6.000 revolutions per minute, the horse power is .000013366. The free air consumption, with 15 per cent. added for clearance and leakage, is .0004109 cubic feet per minute. As the air is not reheated the best economy is not attained and indicator cards and data are not exhibited. Gold and steel are used in the construction, the flywheel, for instance, which was built up having a hub of steel and a rim of gold. Thos. H. Robinson, of Toronto, Ontario, built it.

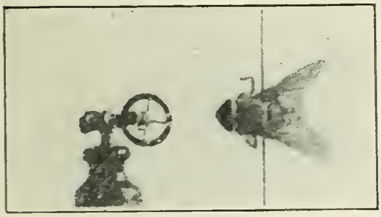


FIG. 1. THE ENGINE FULL SIZE.

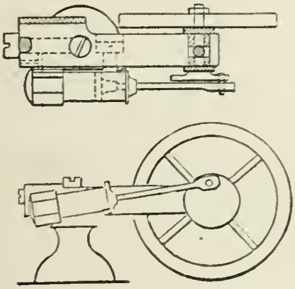


FIG. 2. THE CONSTRUCTION OF THE ENGINE.

ON THE MEASUREMENT OF AIR FLOWING INTO THE ATMOSPHERE THROUGH CIRCULAR ORIFICES IN THIN PLATES AND UNDER SMALL DIFFERENCES OF PRESSURE.*

By R. J. Durley, Montreal, Canada.

Introduction.

1. While engaged in experimental work requiring the measurement of quantities of air flowing at comparatively low pressures, the writer was led to an examination of the available formulae for the discharge of air under such conditions. These formulæ appeared to be insufficient for the purpose in view, and, after some preliminary trials, the experiments described below were made under the writer's supervision, in the Laboratories of the Department of Mechanical Engineering, McGill University, by Messrs. F. E. Sterns and G. M. Smith, Demonstrators in Mechanical Engineering.

2. In these experiments it was desired, first, to ascertain the laws governing the flow of air through circular orifices in thin plates at low heads; and, secondly, to measure the air discharged in such a manner that the experimental conditions could be easily duplicated at any time so that a similar gauging apparatus might be used in the laboratory.

3. Circular orifices bored in thin plates were selected because of simplicity of formation, and it was found that with proper apparatus, such orifices afforded a convenient means of gauging the amount of air discharged by fans, blowers, air engines, air compressors, and the like.

Existing Formulae.

4. The information generally available on the flow of air through orifices at low pressures may be summarized as follows:

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* A paper read before the American Society of Mechanical Engineers.

(*a*) Weisbach's experiments*—These were made on air issuing into the atmosphere, and those made at low pressures gave the values of the coefficient of discharge for orifices 1 and 2.14 centimeter (0.39 and 0.84 inches) diameter when the ratio $\frac{\text{internal pressure}}{\text{external pressure}}$ had the values 1.05 and 1.09. This would correspond, with the barometer at 30 inches, to heads of 1.5 inches and 2.7 inches of mercury, or 22 inches and 37 inches of water nearly, and the coefficient of discharge (c) had values ranging from 0.555 to 0.589 in the formula.

$$v = c\sqrt{2gh},$$

where h is the head in feet of air.

(*b*) Fliegner's equations†—The empirical equation found by Fliegner as expressing results of experiments on the flow into the atmosphere from a reservoir in which the pressure is less than two atmospheres was:—

$$W = 1\ 060\ F\sqrt{\frac{p_a(p_1 - p_a)}{T_1}},$$

where W = weight passing in pounds per second.

F = area of orifice in square inches.

p_1 and pa are absolute pressures in pounds per square inch.

T_1 = absolute temperature in degrees Fahr.

Calculation of Ideal Flow of Air Through an Orifice Under a Small Difference of Pressure.

5. The conditions under which the writer's experiments were carried out rendered it advisable to limit the head to 5 inches of water. It is therefore only necessary here to consider the formulae applying to the flow of air under low pressures—

6. Air at 32 degrees Fahr. and at a pressure of 14.7 pounds per square inch weighs 0.0807 pounds per cubic foot. At 60 degrees Fahr. the weight is therefore 0.0764 pounds nearly.. Under a pressure of five inches of water or 0.1505 pounds per square inch above atmospheric pressure, air at 60 degrees Fahr. would have a weight of $0.0764 \times \frac{14.8505}{14.7} =$ 0.0772 pounds per cubic foot, an increase in density of 0.0008 pounds, or say, 1 per cent. We shall see that this increase in density is so small that the air may be considered, without serious error, as remaining of uniform density during the experiments here described.

7. The consideration of the adiabatic flow of a perfect gas through a frictionless orifice leads to the equation*

$$W = A \sqrt{2g\frac{y}{y-1} \cdot \frac{P_1}{V_1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{y}} - \left(\frac{P_2}{P_1}\right)^{\frac{y+1}{y}}\right]} \quad (1)$$

In this expression

W = weight of gas discharged per second in pounds.

A = area of cross section of jet in square feet.

P_1 = pressure inside orifice in pounds per square foot.

P = pressure outside orifice.

V_1 = specific volume of gas inside orifice in cubic feet per pound.

y = ratio $Kp/Kv = \frac{\text{spec. heat at const. press.}}{\text{spec. heat at const. press.}}$ per pound.

For air, where $y = 1.404$, we have from equation (1) for a circular orifice of diameter d inches, the initial temperature of the air being 60 degrees Fahr. (or 521 degrees abs.),

$$W = 0.0816\, d^2 \sqrt{\frac{P_1}{V_1}\left[\left(\frac{P_2}{P_1}\right)^{1.425} - \left(\frac{P_2}{P_1}\right)^{1\ 712}\right]},$$

or.

$$W = 0\ 000491\ d^2\ P_1 \sqrt{\left(\frac{P_2}{P_1}\right)^{1.425} - \left(\frac{P_2}{P_1}\right)^{1\ 712}} \quad . \quad (2)$$

while, if we measure P_2 in lbs. per square inch,

$$W = 0\ 07058\ d^2\ P_1 \sqrt{\left(\frac{P_2}{P_1}\right)^{1\ 425} - \left(\frac{P_2}{P_1}\right)^{1.712}} \quad . \quad (2a)$$

8. In practice the flow is not frictionless, nor is it perfectly adiabatic, and the amount of heat entering or leaving the gas is not known. Hence the weight actually discharged is to be found from such a formula as (2) by introducing a coefficient of discharge (generally less than unity) depending on the conditions of the experiment and on the construction of the particular form of orifice employed.

9. The above formula is not very convenient for calculation, and for practical purposes

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* See Weisbach, "Der Civilingenieur," vol. 5, 1859, p. 546; also, "Theor. Mech.," 464-6 (5th American Edition), and "Peabody's Thermodynamics," p. 137. † See "Der Civilingenieur," vol. 20, p. 14.

*See note at end of paper, also "Peabody's Thermodynamics," p. 132. 081.

it is better (if the ratio $\frac{P_2}{P_1}$ is nearly unity) to employ a somewhat similar expression, obtained by assuming that the air or gas flows as would a liquid of the same mean density. In other words, we neglect the changes of density and temperature occurring as the air passes through the orifice; and are thus able to obtain a simpler though approximate formula—as follows:—

Let $i =$ difference of pressure (between P_1 and P_2) measured in inches of water.

$T =$ absolute temperature of air (supposed to remain unchanged).

$U =$ velocity of air in feet per second (supposed uniform over whole cross section of orifice).

$V =$ specific volume of air (supposed constant during passage through orifice).

$P =$ mean pressure of air in pounds per square foot.

10. Then the head (measured in feet of air) under which the flow takes place is $h = V(P_1 - P_2)$.

But a pressure of one inch of water $= 5.2$ pounds per square foot, so that

$$h = 5.2\ i\ V.$$

Now $u = \sqrt{2gh}$ and the weight discharged per square foot of orifice per second will be

$$\frac{u}{V} = \sqrt{\frac{2\,g \times 5.2\ i\ V}{V}} = \sqrt{\frac{64.4 \times 5.2\ i}{V}}.$$

But $V = \frac{53.18\ T}{P}$ for air, so that the ideal discharge per square foot of orifice per second will be

$$\sqrt{\frac{64.4 \times 5.2\ i\,P}{53.18\ T}} = 2.509\sqrt{\frac{i\,P}{T}} \text{ pounds.*}$$

For an orifice of diameter d inches the ideal discharge will be

$$W = \frac{0.7854 d^2}{144} \times 2.509 \sqrt{\frac{i\,P}{T}}$$

$$= 0.01369\ d^2\sqrt{\frac{i\,P}{T}} \ \ldots\ldots\ldots (3)$$

In the usual case, in which the discharge takes place into the atmosphere, P is approximately 2,117 pounds per square foot and

$$W = 0.6299\ d^2\sqrt{\frac{i}{T}} \ \ldots\ldots\ldots (4)$$

This equation is, of course, of the same form as Fliegner's well known formula.

11. It will be found that up to a pressure of about 20 inches of water (or 0.722 pounds per square inch) above the atmospheric pressure, the results of formulae (2) and (4) agree very closely. At higher differences of pressure divergence becomes noticeable. For example, if $P_1 - P_2 = 60$ inches of water or 2.166 pounds per square inch, we have from (4), if $P_2 =$ 2.117 pounds per square foot and $T = 60$ degrees Fahr.)—for a 3 inch orifice.

$$W = 06299\ d^2\sqrt{\frac{i}{T}} = 0.6299 \times 9 \times \sqrt{\frac{60}{521}}$$

$= 1.892$ lbs. per second. In the case of adiabatic expansion, from (2) we get

$$W = 0.0004901\ d^2\ P_1\sqrt{\left(\frac{P_2}{P_1}\right)^{1.425} = \left(\frac{P_2}{P_1}\right)^{1.712}}$$

$$= 0\ 00049011 \times 9 \times 2,422$$

$$\sqrt{.8735^{1\ 425} - .8735^{1\ 712}}$$

$$= 0.00049011 \times 9 + 2.422 \times 0.1766$$

$$= 1885 \text{ lbs. per second.}$$

The discharge as calculated by Fliegner's formula would be

$$1.06 F\sqrt{\frac{P_2(P_1 - P_2)}{T}} = 1.06 \times 7.07$$

$$\times \frac{14\ 7 \times 2.166}{521}$$

$$= 1.06 \times 7.07 \times 0.2471$$

$$= 1.852 \text{ lbs. per second.}$$

Even at the low pressures here considered Fliegner's rule gives results agreeing much more nearly with those of equations (2) and (4) than with the discharge actually measured. Thus for a 3 inch orifice we have:—

IDEAL DISCHARGE (pounds per second,	Head=1	2	3	4	5 ins of water.
By equation (4)....	0.248	0 351	0.430	0 496	0.555
By equation (2)....	0.248	0 350	0.429	0.495	0.553
Discharge by Fliegner's rule........	0.232	0.338	0.415	0.485	0.535
Actual weight of air per second as found from experiments and curves...........	0.149	0.210	0.257	0.296	0.331

12. It is thus evident that the above formulae for the ideal amount of air discharged require the use of a coefficient of discharge in

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* Thus when $P = 2{,}117$ lbs. per square foot and T is 521° (60° F.) the ideal discharge per second per square foot of orifice will be as follows:

i	1	2	3	4	5	inches of water.
W	5 060	7.155	8.764	10.12	11.312	lbs. per second.

order that the actual discharge may be computed by their aid, and to determine such a coefficient of discharge for a given orifice, it is necessary to measure the actual discharge and compare it with the amount calculated by such a formula as (2) or (4). These two formulae give results which differ so little within the limits of pressure here dealt with, that the latter has been chosen for use in this paper. Fig. 1 shows the ideal discharge calculated by the two formulae for a 3 inch orifice for various heads; their close agreement, within limits even greater than those of the experiments, is evident.

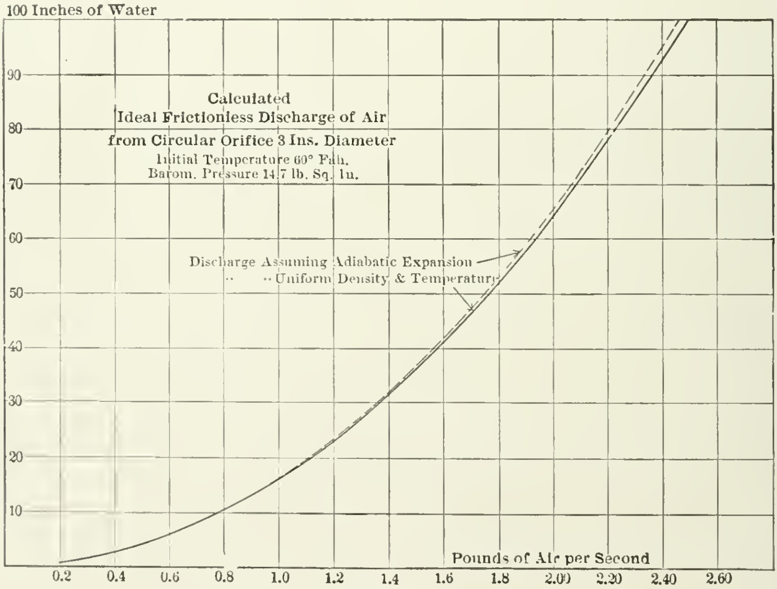

FIG. 1.

13. The numbers given in table IV are the values of C in the expression,

Actual discharge in pounds per second

$$= 0.6299\, Cd^2 \sqrt{\frac{i}{T}}$$

It is, of course, understood that they hold good only for orifices of the particular form experimented with, and bored in plates of the same thickness.

Scope of Experiments.

14. The largest air compressor available was a two stage belt driven machine capable of compressing about 350 cubic feet of free air per minute to a pressure of 100 pounds per square inch.—The air delivered by this compressor was stored in cast iron reservoirs whose combined volume was about 90 cubic feet. With this apparatus it was not found possible to discharge more than 8-10 of a pound of air per second without getting too rapid a fall of pressure in the reservoirs, and it was accordingly determined to limit the experiments to orifices less than 5 inches diameter and to work only with differences of pressure up to 5 inches of water. The data obtained, however, made it possible to continue the curves with reasonable accuracy so as to give coefficients of discharge for orifices up to, say, six inches diameter and for differences of pressure up to six inches of water.

Description of Apparatus and Methods of Experiment.

15. The general arrangement of the apparatus is shown in Fig. 2. The reservoirs R discharged into the gauging box B through a quick closing gate valve V_1 and a regulating valve V_2. After leaving these valves the air passed at low pressure through a heater H, consisting of a number of thin sheet iron boxes immersed in a tank of water whose temperature could be varied as desired.

16. The gauging box, shown in detail in Fig. 3, was of 1 inch pine made air tight by pitch on the inside. It was 6 feet long and 10

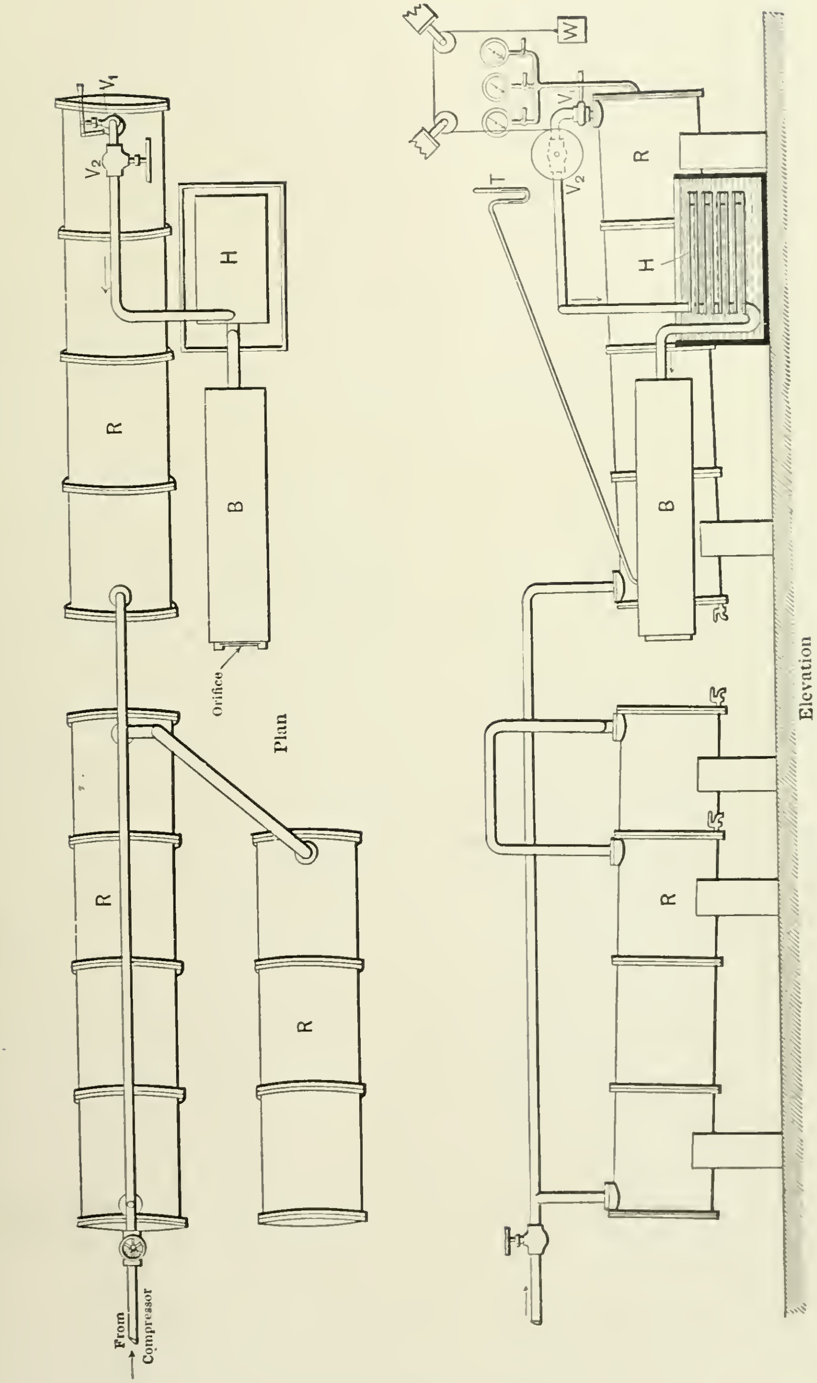
V1
V2
H
R
B
Orifice
Plan
R
R
From Compressor
W
V1
V2
T
R
H
B
R
Elevation

FIG. 2.

inches by 10 inches inside dimensions. Near the end at which the air entered, suitable baffle plates were placed as shown. The connection for the U tube for measuring the head was placed near the middle of the box.

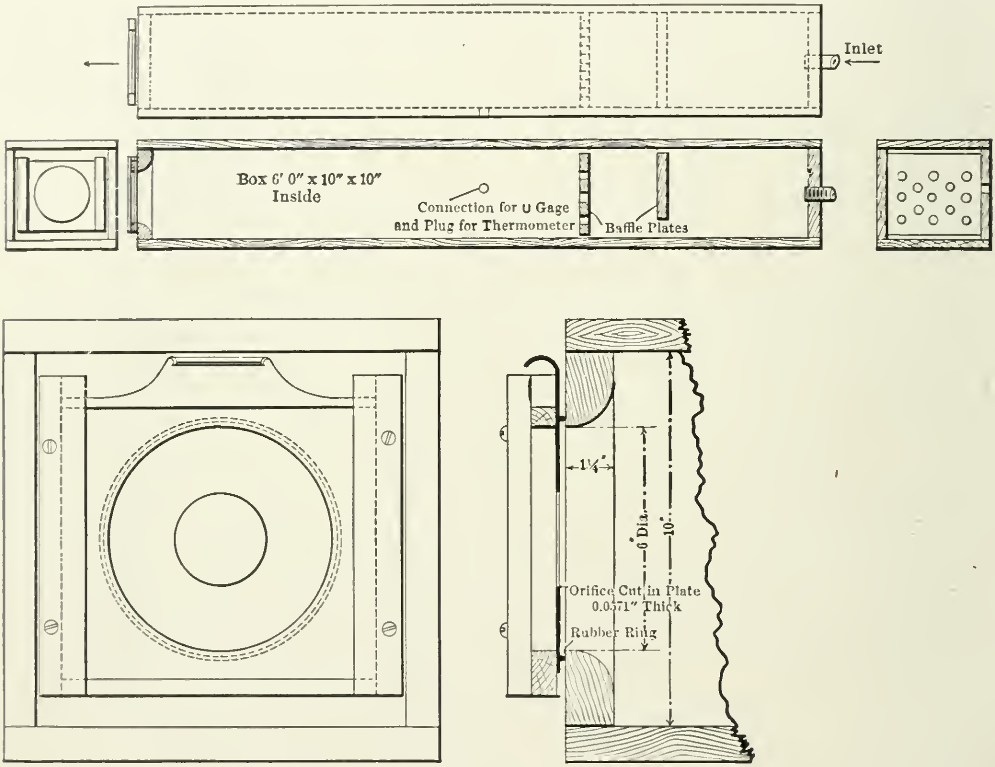
Inlet
Box 6' 0" x 10" x 10" Inside
Connection for U Gage and Plug for Thermometer
Baffle Plates
1¼"
6 Dia.
10"
Orifice Cut in Plate 0.0571" Thick
Rubber Ring

FIG. 3. DETAILS OF GAUGING BOX AND ORIFICE.

17. The air reservoirs (*R*, Fig. 2) were built up of cylindrical flanged castings connected by bolts. The joints were made with asbestos millboard, soaked in boiled oil, and as it was necessary to use fairly high pressure in the reservoirs in order to get experiments of sufficient length on large orifices, some difficulty was experienced in keeping the joints tight. The leak was carefully measured and it was found that at the highest pressure it did not exceed 0.0005 pounds per second, while at low pressure its amount was negligible. The results of the leak tests were correct to within at least 10 per cent., and therefore the greatest possible error made in allowing for the leak would be 0.00005 pounds per second, not more than 3 per cent. of the whole discharge on the 5-16 inch orifice, and decreasing to 1-100 of 1 per cent. on the 4 inch orifice.

18. The orifices were carefully bored in iron plates No. 15 Brown & Sharpe Wire Gauge (0.057 inch thick), and were true to size within 5-1,000 inch. In calculating the ideal discharge, the size measured correctly to within 1-1,000 inch by a vernier caliper, was used in each case. The effect on the result due to inaccuracy in measurement of orifice diameter would therefore not exceed 7-10 of 1 per cent., on the 5-16 inch orifice, while on the 1 inch orifice it would be less than 1-5 of 1 per cent., and on larger orifices would be smaller still.

19. The orifice plates were secured to the end of the box in such a way as to be easily removed and interchanged. The joint between plate and box was made tight with rubber cord.

20. The temperature of the air in the box was measured by a thermometer placed near the middle of its length. This reading was checked at intervals by means of a thermometer suspended lengthwise in the jet, and was

never found to vary more than one-tenth of 1 per cent. from the actual absolute temperature in the orifice, except in the high temperature trials. In these trials three thermometers placed at different distances from the orifice were used and from their readings the actual temperature in the orifice was deduced.

21. Standard mercury thermometers were used to measure the temperature of the air in the reservoir. They were inserted through rubber packer stuffing boxes so that the bulb came into actual contact with the air and was therefore exposed to the pressure in the reservoir. This pressure increased the reading about 1 degree for every 100 pounds, which was allowed for correctly to within 0.05 degree. The thermometers were graduated in degrees and tenths Fahr., and were such that temperatures read from them were correct to within 0.1 degree. The error on 500 degrees (the approximate absolute temperature) would therefore be less than 0.03 of 1 per cent.

22. For measuring the pressure in the gauging box, the U tube *T* (Fig. 2) was placed in a convenient position for the eye of the person operating the regulating valves and was connected to the box by rubber tubing. A scale of half inches divided on blackened glass was placed behind one leg of the U tube so as to read inches of head, and was illuminated by an incandescent light suspended behind it. To avoid parallax the scale was read through a small telescope fastened with a clip so as to slide up and down the leg of the U tube. The scale was graduated correctly to within 2-1,000 inch; the resulting possible error would therefore not exceed 4-10 of 1 per cent. on the 1 inch head and would be about 1-10 of 1 per cent. on the 4 inch head. As the meniscus was magnified considerably by the telescope, the error in reading its position would probably not be more than 2-1,000 inch, leading to an error of the same amount as that just mentioned, in the final result.

23. The pressure in the reservoir was measured by Standard Crosby gauges which were carefully calibrated on the dead weight gauge tester. On trials on the smaller orifices a gauge graduated in pound per square inch was used. This gauge could be read correctly to within 1-10 of a pound per square inch, parallax being avoided by aligning the pointer with its shadow thrown on the dial by a small lamp suspended opposite the center of the gauge. Where the difference between the initial and final pressures was not less than fifty pounds per square inch, the error would not exceed 1-5 of 1 per cent. As it was very difficult to keep the head constant when the reservoir pressure became low in trials on the larger orifices, the range of pressure was shortened for these trials, and gauges graduated in tenths of a pound were then used, giving readings correct to 0.02 pound, so that the error on a range of twenty pounds would not exceed 1-10 of 1 per cent.

24. The reservoirs were provided with drain cocks so that water condensing from the vapor in the air pumped in could be drawn off. The drains were opened so frequently that never more than a pound of water was collected, which would make an error of less than 1-40 of 1 per cent. on a reservoir volume of 90 cubic feet.

25. In certain trials on the smaller orifices, a small wrought iron reservoir (volume 4.294 cubic feet) was used with the object of getting a wide range of pressure in a short time, and also of checking results obtained from the large reservoir. From this reservoir there was no leak, and other errors were of the same order as those previously mentioned.

26. As mentioned above, some difficulty was experienced in keeping the pressure uniform in the gauging box when the discharge was great. This was partially remedied by stopping the trial before the pressure in the reservoir had fallen too low. It was almost completely obviated by attaching to the spindle of the regulating valve a grooved pulley and leading a cord from its rim over guide pulleys to a weight (*W*, Fig. 2) of about ten pounds. It was then found that the valve could be opened much more uniformly by resisting the action of the weight than by moving the valve wheel directly. By this means the fluctuations were reduced to less than 2 per cent. of the head, and the trials were so long that the error in measuring the head was substantially only that already mentioned due to inaccurate reading and to imperfect graduation of the scale.

27. Time was measured on some of the trials by an ordinary watch, on others by a stop watch, and on others by a recording chronograph. The ordinary watch was used on trials of 5 minutes duration and longer, and as it could be read correctly to within half a second, the error in an experiment last-

ing 20 minutes would not exceed 0.08 of 1 per cent. On trials of two or three minutes the stop watch was used with an error less than 1-6 of 1 per cent. The chronograph, which made its records automatically, was used on trials of less than two minutes duration and gave readings correct to within 1-50 second. As the shortest trial occupied at least 30 seconds, the error would not be greater than 1-15 of 1 per cent. The trials were started and stopped by means of a quick opening gate valve *V* (Fig. 2), placed between the regulating valve and the reservoir, the chronograph circuit being closed as the handle of the gate valve passed its mid position.

28. The volume of the reservoir was measured by weighing the amount of water necessary to fill it. The water was weighed in tanks holding 100 pounds, on scales reading correctly to half an ounce, so that the error could not exceed 1-16 of 1 per cent. The total volume of the three parts of the reservoir and the piping was found to be 91.881 cubic feet. The various errors just discussed are enumerated in Table I.

(*To be Concluded.*)

TABLE I.

Sources of Error.

Operation.	Error in Per Cent.	
	5/16-inch Orifice. 1-inch Head.	4-inch Orifice. 4-inch Head.
Allowing for leak	±3.0	±0.01
Reading pressure in reservoir	±0.2	±0.2
Reading temperature in reservoir.........................	±0.03	±0.03
Finding volume of temperature in reservoir...............	±0.07	+0.07
Allowing for condensed water in reservoir.	—0.025	—0.025
Measuring area of orifice	±0.7	±0..05
Taking temperature in box................................	±0.1	±0.1
Graduating *U* tube	±0.4	±0.1
Reading from tube	±0.4	±0.1
Measuring time	±0.08	±0.06

TABLE II.

Experiments Showing Effects of Temperature of Air.

Diameter of orifice, 1 inch. Difference of pressure, 3 inches of water.

1	2	3	4	5	6
Expt. No.	Temperature in Gauging Box. Deg. Fahr., abs.	Actual discharge as measured. Lbs. per Second.	Corrected discharge as taken from curves. Fig. II. Lbs. per Second.	Square Root of abs. Temperature.	Product Column 5 × Column 4
151	516.1	0.02938	0.02910	22.72	0.6612
152	525.5	0.02901	0.02895	22.92	0.6632
153	525.9	0.02934	0.02893	22.93	0.6634
154	526.3	0.02881	0.02890	22.94	0.6630
155	537.0	0.02827	0.02860	23.17	0.6627
156	542.4	0.02864	0.02850	23.29	0.6638
157	546.8	0.02832	0.02835	23.38	0.6628
158	548.1	0.02984	0.02830	23.41	0.6626
159	549.6	0.02767	0.02825	23.45	0.6625
160	561.8	0.02637	0.02795	23.70	0.6624
161	563.3	0.03004	0.02790	23.73	0.6621
162	567.6	0.02636	0.02775	23.82	0.6610

TABLE III.

Mean Discharge in Pounds per Square Foot of Orifice per Second, as Found from Experiments.

Diameter of Orifice. Inches.	1-inch Head Discharge per Sq. Ft.	2-inch Head Discharge per Sq. Ft.	3-inch Head Discharge per Sq. Ft.	4-inch Head Discharge per Sq. Ft.	5-inch Head Discharge per Sq. Ft.
0.3125	3.060	4.336	5.395	6.188	7.024
0.5005	3.012	4.297	5.242	6.129	6.821
1.002	3.058	4.341	5.348	6.214	6.838
1.505	3.050	4.257	5.222	6.071	6.775
2.002	2.983	4.286	5.284	6.107	6.788
2.502	3.041	4.303	5.224	5.991	6.762
3.001	3.078	4.297	5.219	6.033	6.802
3.497	3.051	4.258	5.202	5.966	6.814
4.002	3.046	4.325	5.264	5.951	6.774
4.506	3.075	4.383	5.508	6.260	7.028

TABLE IV.

Coefficient of Discharge for Various Heads and Diameters of Orifice.

Diameter of Orifice. Inches.	1-inch Head.	2-inch Head.	3-inch Head.	4-inch Head.	5-inch Head.
$\frac{5}{16}$	0.603	0.606	0.610	0.613	0.616
$\frac{1}{2}$	0.602	0.605	0.608	0.610	0.613
1	0.601	0.603	0.605	0.606	0.607
$1\frac{1}{2}$	0.601	0.601	0.602	0.603	0.603
2	0.600	0.600	0.600	0.600	0.600
$2\frac{1}{2}$	0.599	0.599	0.599	0.598	0.598
3	0.599	0.598	0.597	0.596	0.596
$3\frac{1}{2}$	0.599	0.597	0.596	0.595	0.594
4	0.598	0.597	0.595	0.594	0.593
$4\frac{1}{2}$	0.598	0.596	0.596	0.593	0.592

Weight of air discharged per second $= 0.6299\, Cd^2 \sqrt{\frac{i}{T}}$ lbs. (Barometer at 30 inches.)

TABLE V.

Corrected Actual Discharge in Pounds per Second at 60 Degrees Fahr. and 14.7 Pounds Barometric Pressure for Circular Orifices in Plate 0.057 Inches Thick.

Head Inches	Diagram of Orifice in Inches										
	0.3125	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
$\frac{1}{2}$	0.00114	0.00293	0.0117	0.0263	0.0468	0.0732	0.105	0.143	0.187	0.247	0.292
1	0.00162	0.00416	0.0166	0.0373	0.0663	0.103	0.149	0.202	0.264	0.334	0.413
$1\frac{1}{2}$	0.00199	0.00510	0.0203	0.0457	0.0811	0.127	0.182	0.248	0.323	0.409	0.505
2	0.00231	0.00590	0.0235	0.0528	0.0937	0.146	0.210	0.285	0.373	0.471	0.582
$2\frac{1}{2}$	0.00259	0.00662	0.0263	0.0591	0.105	0.163	0.235	0.319	0.416	0.526	0.649
3	0.00285	0.00726	0.0289	0.0648	0.115	0.179	0.257	0.349	0.455	0.575	0.710
$3\frac{1}{2}$	0.00308	0.00786	0.0312	0.0700	0.124	0.193	0.277	0.377	0.491	0.621	0.766
4	0.00330	0.00842	0.0334	0.0749	0.133	0.206	0.296	0.402	0.525	0.663	0.817
$4\frac{1}{2}$	0.00351	0.00895	0.0355	0.0794	0.141	0.219	0.314	0.426	0.556	0.702	0.865
5	0.00371	0.00945	0.0375	0.0838	0.148	0.231	0.331	0.449	0.586	0.739	0.912
$5\frac{1}{2}$	0.00390	0.00993	0.0393	0.0879	0.155	0.242	0.347	0.471	0.613	0.774	0.953
6	0.00408	0.0104	0.0411	0.0918	0.162	0.252	0.362	0.492	0.640	0.808	0.995

TABLE VI.

No. of trial.	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs	Reservoir				Box Temp. Abs.	Actual discharge Lbs Sec	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressures		Abs Temperature				
				Initial.	Final.	Initial.	Final.			
1	5/16	1	1,260	88.8	83.4	520.1	520.0	518.6	.002033	.001628
2	"	1	3,900	95.4	78.7	520.1	520.0	518.5	.002040	.001631
3	"	2	1,200	71.8	64.8	519.9	519.8	520.0	.002758	.002430
4	"	2	3,600	78.2	58.7	520.0	519.8	520.0	.002592	.002264
5	"	2	508	78.2	19.4	542.8	531.5	534.0	002463	.002236
6	"	3	1,200	57.6	49.7	520.0	519.8	521.0	.003149	.002879
7	"	3	1,200	49.7	41.8	519.8	519.8	521.3	.003152	.002912
8	"	3	3,600	57.6	34.5	520.0	519.8	521.3	.003072	.002832
9	"	4	1,800	92.14	78.22	520.9	520.6	521 4	.003677	.003292
10	"	4	1,560	78.22	66.31	520.6	520.5	520.5	.003637	.003296
11	"	4	4,080	92.14	60.79	520.9	520.4	520.2	.003665	.003262
12	"	4	373	92.5	27.6	542.3	530.6	531.2	.003699	.003333
13	"	5	2,400	59.9	39.8	520.4	519.9	521.5	.003998	.003748
14	"	5	2,700	101.18	77.39	522.1	520.1	522.2	.004157	.003751
15	"	5	3,900	101 18	67.27	522.1	520.5	522.3	.004109	.003723

TABLE VII.

No. of trial.	Diam. of Orifice ins.	Head ins. water	Duration of trial Secs.	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs Pressures.		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
16	1/2	1	3,398	96.8	63.7	529.2	523.4	524.5	.004482	.004123
17	"	1	1,153	96.8	85.0	529.2	524.0	524.4	.004468	.004067
18	"	1	2,245	85.0	63.7	524.0	523.4	524.5	.004489	.004155
19	"	2	2,427	96.8	64.7	524.9	522.6	524.4	.006227	.005869
20	"	2	1,276	96.8	79.9	524.9	523.2	524.4	.006200	.005822
21	"	2	1.151	79.9	64.7	523.2	522.6	524.1	.006247	.005924
22	"	3	2,992	103.0	54.6	528.8	523.1	524.9	.007518	.007177
23	"	3	1,081	103.0	85.0	528.8	524.1	524.5	.007482	.007078
24	"	3	1,911	85.0	54.6	524.1	523.1	525.0	.007541	.007236
25	"	4	2,126	93.8	54.6	525.3	522.9	523.4	.008674	.008346
26	"	4	1,036	93.8	74.7	525.3	523.5	523.0	.008600	.008322
27	"	4	1,090	74.7	54.6	523.5	522.9	523.8	.008744	.008457
28	"	5	981	94.8	74.7	526.4	524.6	518.9	.009561	.009185
29	"	5	533	65.7	54.6	524.3	522.8	521.1	.009757	.009457

TABLE VIII.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	Reservoir				Box Temp. Abs.	Actual dischatge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressures.		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
30	1	1	412	87.0	72.5	522.6	521.0	519.1	.01643	.01603
31	1	1	833.67	94.17	63.39	522.1	521.4	513.8	.01752	.01699
32	1	1	870.14	93.51	60.90	521.1	518.8	515.5	.01773	.01723
33	1	2	1,157	92.1	32.6	529.5	518.0	520.0	.02389	.02357
34	1	2	587	62.5	32.6	519.6	518.0	520.2	.02432	.02406
35	1	2	1,147	92.1	32.6	533.1	518.2	520.4	.02384	.02353
36	1	2	587	62.5	32.6	520.0	518.2	520.1	.02424	.02398
37	1	3	478	60.5	30.6	520.1	518.6	522.1	.02984	.02963
38	1	3	748	83.9	36.5	524.5	520.6	521.7	.02990	.02963
39	1	3	1,020	91.3	27.5	522.6	518.2	516.1	.02967	.02925
40	1	4	676	94.8	44.8	523.4	517.0	520.1	.03477	.03440
41	1	4	658	94.8	44.8	535.8	517.4	524.6	.03415	.03393
42	1	4	776	91.8	34.6	528.8	515.4	519.8	.03414	.03379
43	1	5	593	94.8	44.8	538.8	518.5	518.5	.03758	.03715
44	1	5	588	94.8	44.8	537.9	518.3	518.8	.03798	.03756
45	1	5	587	94.8	44.8	538.0	518.3	518.7	.03806	.03764

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., . Managing Editor
P. F. KOBBÉ, JR , . . Business Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. SEPTEMBER, 1906. No. 7.

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REFUGE CHAMBERS IN COAL MINES.

We publish in this issue a paper read by Mr. J. L. Dixon, E. M., at the meeting of the Mining Institute of Pittsburg, June 20th last. Mr. Dixon has written very intelligently upon the subject, "Uses of Compressed Air in Coal Mines." Anything on this subject from Mr. Dixon is of interest and value because of its practical nature. Mr. Dixon is an engineer thoroughly familiar with coal mining, especially in connection with power plants. He does not attempt to claim everything for compressed air, but he specifies those special uses of compressed air which have made it so invaluable in coal mining. For instance, haulage, by locomotives and by stationary engines, coal cutting and drilling by percussive and rotary machines, pumping, shearing in entries and rooms, and to those useful applications, with which most mining engineers are familiar, he adds the "Proposed method of saving life by and with compressed air." This suggestion has the virtue of novelty and it is worthy of the serious consideration of mining men.

It is proposed to equip every mine with life-saving stations or chambers of refuge. These chambers might be excavated in the coal and approached by long, narrow entrances which could easily be rendered explosion proof. The chambers are to be connected with the surface by a compressed air line, which can be put down a bore hole directly into the chamber. It has recently been found that rotary core drills which are capable of boring holes of large diameter, and without the use of diamonds are especially suited for boring entry holes into mines, and there appears to be no difficulty in the way of a special compressed air pipe line leading to these refuge chambers and serving to keep them supplied with fresh air in the event of an explosion. To save one life by a safeguard of this kind would in itself warrant the expenditure, and we trust that those interested in the subject will read all that Mr. Dixon has to say and that they will aid in putting the suggestion to practical use.

DENATURED ALCOHOL AGAIN.

In recent issues of COMPRESSED AIR we have devoted considerable space to the subject of denatured alcohol, its possible future and methods of manufacture. Now comes word from the Department of Agriculture that an investigation into the possibilities of alcohol as a fuel in small gas engines is about to be carried out by Prof. Chas. E. Lucke, of Columbia University, New York City, as a result of the passage of the bill allowing the sale of alcohol without the internal revenue tax. The Department of Agriculture has decided to publish a bulletin on the first of January next, when this law goes into effect, giving the public a collection of the best obtainable data on the use of denatured alcohol as a motive power in internal combustion engines. For this purpose it has retained Prof. Lucke as the department expert to conduct the necessary investigations in the laboratories of Columbia University.

When this law goes into effect very large quantities of denatured alcohol will be used as fuel in automobiles, boats, and for stationary work. The advantages of alcohol for these purposes are numerous, especially the lack of odor in combustion and safety from fire over kerosene or gasolene, because it is possible to put out an alcohol fire with water, where it is impossible to extinguish either of the others in this way.

In spite of the fact that a great deal has been done to secure the passage of the bill there is very little information of value on the subject to be found. Prof. Lucke will collect the results of the experiments conducted on the use of alcohol in engines which have been carried out both here and abroad and will expand the information by further experiments, inviting all those who have patents on vaporizers, carburettors or complete engines to submit the apparatus to tests in his laboratory. These tests will be conducted without any expense whatever to the public, except the transportation of apparatus, the reports of the test being published in the before mentioned bulletin. Any data or shipments should be addressed to Prof. Chas. E. Lucke at Columbia University, and they will be returned when the work is completed, due acknowledgement being given for the assistance rendered. It is to be hoped that, should any of our readers possess apparatus of this nature, that they will take advantage of this offer.

SUPERHEATED STEAM.

We note in a recent issue of the *Engineering Record* a very able editorial on the subject of superheated steam in which are brought out points of which very few people possess a clear understanding. For instance, not many engineers realize that the improvement in economy from the use of superheated steam is not due, except in very small measure, to the mere fact of increase in temperature in the steam fed to the engine, or to the influence of such increase in temperature on what is commonly known as the thermodynamic or ideal efficiency of the engine. One of the erroneous views which has occasionally misled engineers is that the improvement in economy traces back to the familiar law of thermodynamics which expresses the economy of the ideal Carnot cycle in the form $(T_1 - T_2) \div T_1$ where T_1 and T_2 are the upper and lower temperatures of the isothermal paths along which all the heat is either received or rejected. Reasoning then that superheating means an elevation of temperature in the entering steam, it has seemed an easy step to ascribe the general improvement in economy to a corresponding direct increase in the ideal or thermodynamic efficiency of a superheated steam cycle. A moment's thought shows the error in this assumption. This formula quoted above refers to the Carnot cycle, and in which the heat given to the working substance is all communicated at the upper temperature, T_1 while in the case of superheated steam by far the larger part of the heat is communicated at the temperature of boiling, distinctly lower than the upper or superheat temperature, only a comparatively small part of the heat being communicated at the gradually increasing temperature due to the superheat condition. If, indeed, the steam could be expanded in a truly adiabatic manner and the remainder of the cycle could be carried out strictly according to the Carnot ideal, we should still fall far short of any such ideal economy as expressed in the formula $(T_1 - T_2) \div T_1$. In a typical case and in commercial terms, the conditions would be somewhat as follows: The heating of one pound of water from the lower temperature to that of boiling would mean the investment of about 230 B.t.u. at an ideal efficiency of about 14 per cent. The production of one pound of saturated steam would mean the further investment of about 860 B.t.u. at an ideal efficiency of about 28 per cent., while the superheating of this by 120° would mean the investment of some 66 B.t.u. at an ideal efficiency of some 32 per cent. The average working efficiency or earning power of this investment is seen to be, even in the ideal case, far below the 36 per cent., which would represent the value as given by the formula quoted above, where T_1 is superheat temperature. In fact, the amount of heat involved in the operation of superheat is comparatively so small that it can have, so far as pure thermodynamic principles are concerned, but slight influence on the general efficiency of the cycle.

Actually the gain comes from an entirely different direction—in the case of reciprocating engines to which the present discussion more especially applies, from the supression in varying degree of the loss due to cylinder condensation and involving the activity of a secondary or "cast-iron" cycle, as a result of which a considerable amount of heat may be shunted past the working cycle of the engine proper, and find its way to the condenser without having taken any active part in the work-producing cycle of the engine. The general nature of these operations within the steam engine cylinder is, of course, well known to engineers, and it is by reducing the readiness of transfer between the cast-iron and the working substance that the use of superheated steam may result in an improvement in economy. The improvement is due, therefore, not to the lifting of the ideal efficiency, but rather by a closer approach to the existing ideal which is fixed by the conditions of the case in hand.

Another point brought out by our contemporary concerns the common method of reporting steam engine trials. The result of such trials are very commonly given in pounds per horse-power hour. The misleading character of this unit is too well known to need extended comment. The engine is not properly a steam engine, but rather a heat engine and the only consistent method of stating economy results must be in terms of heat expended per unit of power developed. From the very facts of the case statements of economy in terms of pounds of superheated steam per horse-power hour are entirely misleading in comparison with similar results for an engine using saturated steam, and unduly favorable to the former. Thus, in the case of two engines using in one case, say 13 lbs. of saturated steam and in the other 12.5 lbs. of superheated steam, the latter may in fact be less economical of the two engines, a relation which would be at once shown by the expression of economy in terms of thermal units rather than pounds of steam. No definite meaning can therefore be attached to the report of a test of an engine using superheated steam in which the results are stated in pounds of steam per horse-power hour, and the engineer who uses such results without transforming them into thermal units is sure to be misled at the very point which should supply him with accurate data for his guidance.

THE ENGINEERING TIMES IN NEW FORM.

The July 12th issue of the *Engineering Times*, published at 6 Bouverie street, Fleet street, London, E. C., England, comes to us in new form which, say the publishers, they have, after mature deliberation, decided is better fitted for the purpose they have always had in view. The paper in its new form is 9¾x 13¼ inches in size and is handsomely bound in heavy cover paper. It contains twenty pages of reading matter, printed on heavier paper than formerly and a special feature is a handsome supplement illustrating the inauguration of the new Argyll Works at Alexandria. We think the paper should be congratulated upon its new and improved appearance.

TRADE PUBLICATIONS.

Sargent Steam Meter Company, First National Bank Building, Chicago. Booklet describing and illustrating a new meter for measuring the quantity of steam used in an engine. This meter may be located anywhere in the steam line and will render an exact account of the quantity of steam flowing through it, irrespective of pressure. It shows at a glance the quantity of steam being used by any engine, steam pump, heating system or drying room.

The W. G. Leale Company, 119 Mission street, San Francisco, Cal.. Booklet, entitled "A New Process of Pumping," being a description of the Starrett System of pumping by compressed air as adapted to mines and other places where an economical, high duty compressed air displacement pump is applicable.

Ingersoll-Rand Company, 11 Broadway, New York. Booklet, form 73-A, giving short descriptions on various methods of pumping by means of the Air Lift System, including Pohle Method, the Central Pipe System and the Saunders System.

Sullivan Machinery Company, Railway Exchange Building, Chicago. Booklet, form 103, illustrating and describing methods of core drilling, both by power drills and hand drills. Also Booklet, form 102, devoted to coal mining by machinery and describing the Sullivan "Puncher" Pick Machine.

Chicago Pneumatic Tool Company, Fisher Building, Chicago. Special Circular No. 50, devoted to electrical tools and accessories for use in shops, shipyards, foundries, etc

H. D. Crippen Manufacturing Company, 25 Broad street, New York. Catalogue No. 10, devoted to a comprehensive description of the Box Electric Drill for use in mines, quarries, contract work, etc. This catalogue also contains full information and net prices on the cost of installing electric drills, electric hoists, gas engines, oil engines, electric generator sets, and everything for a complete electric drill installation.

De La Vergne Machine Company, foot of East 138th street, New York. A 48-page pamphlet describing the various types of horizontal and vertical ammonia compression refrigerating machines and equipment for ice plants, breweries, packing houses, etc. Illustrated with many fine half-tones and views of plants installed in various parts of the world.

Rockwell Engineering Company, 26 Cortlandt street, New York. Eighteen-page booklet, devoted to high pressure oil burners, fuel oil pumping systems, positive pressure blowers, etc.

Whiting Foundry Equipment Company, Harvey, Ill. Catalogue No. 45, a profusely illustrated book devoted to Electric Traveling Cranes, Improved Air Hoists and other Cranes for foundries, machine shops, rolling mills, power plants and railroad service.

Hanna Engineering Works, 820 Elston avenue, Chicago, Ill. Catalogue No. 3, second edition, handsomely illustrated and devoted to Hanna Riveters, Screen Shakers, and other labor saving pneumatic tools and appliances.

Ingersoll-Rand Company, 11 Broadway, New York. Catalogue No. 383, Edition of 1906, devoted to the Temple-Ingersoll Electric-Air Rock Drill for mining, tunnelling, quarrying and general rock excavation and containing much data of both a practical and theoretical nature regarding electric wiring, engine and generator sizes, weights of wire, etc., with complete records of recent performances.

Stanley-G. I. Electric Manufacturing Company, Pittsfield, Mass. Bulletin No. 149, illustrating and describing Polyphase Induction Motors. Also Bulletins Nos. 608, 778 and 785, devoted to new G. I. Flush Pocket Wall Receptacles, Circuit Breakers, and the "K-9" Arc Lamp for multiple alternating current circuits.

Baldwin Locomotive Works, Philadelphia, Pa. Record of Recent Construction, No. 57. A handsomely illustrated description of the recent types of locomotives constructed by this company, giving full general dimensions of the engine parts.

Manning, Maxwell & Moore, Inc., 85-87-89 Liberty street, New York. A full stock list of machine tools for blacksmiths, boilermakers, builders, carpenters, foundries, machine shops, etc. These machines being kept in stock for immediate delivery.

THE cooling of air while it is being compressed, and reheating it for use in engines, are matters of great importance. If the air is cooled as it is being compressed, the volume will be much smaller, under a given pressure, than the same amount of air would occupy if allowed to retain the heat of compression. Then again, if the compressed air is heated just before it enters the engine, the volume will be increased, while the same pressure is maintained.

INDUSTRIAL.

COMPARATIVE TEST OF LARGE LOCOMOTIVE AIR PUMPS.

When Mr. George Westinghouse invented the locomotive air pump no one foresaw the degree of prominence that instrument was destined to attain in the conduct of railway transportation. That it is inseparably connected with the brake system is apparent, for without it the air brake would be useless, and without air brakes railway trains could not be operated with anything like the present degree of efficiency, to say nothing of the safety factor which the brake constantly affords. Since the advent of air brakes numerous designs of air pumps have been brought out, each answering its intended purpose, but during these years of pump development the chief efforts have been centered in designing instruments occupying little space, light in weight and of sufficient air producing capacity to supply the needs, these desiderata being looked upon as of greater importance than designs contributing to steam economy.

With the advent, however, of High Speed Brakes, long trains of air-braked cars and numerous "parasites" such as bell ringers, track sanders, water scoops, air pressure for Pullmans, and other accessories on engines and cars, all contributing through operation and leakage to exactions on the air pump, has been created a demand for pumps of great air producing capacity until a stage of steam consumption has been reached the result of which is a serious drain upon the coal pile.

It is a generally accepted belief that the Westinghouse 11-inch pump was of ample capacity to supply air for all conditions of train service, but when, a year or more ago, the New York Air Brake Company placed upon the market a duplex pump of considerably greater capacity than the 11-inch pump it was received by many railroad men with much favor, being looked upon as an instrument more capable of meeting modern requirements than any of its predecessors.

It is evident that the sentiment of those using air pumps is in the direction of abnormal air capacity, as compared to former practice, and, to those skilled in the art, that the combination of such capacity and steam economy cannot be obtained with simple pumps. The Westinghouse Air Brake Company, therefore, has produced a pump of very superior capacity as compared to any heretofore used on locomotives and with a factor of steam economy far in excess of anything previously attempted.

The advent of this pump has created no little interest and favorable comment on the part of railway officers who, upon investigation, recognized its simplicity, capacity, and economical qualities. With a view of determining in a practical way the capabilities of this type of air compressor, a comparative test of the Westinghouse Compound and the New York No. 5 Duplex Pumps was somewhat recently made by the Lake Shore & Michigan Southern Railway Co. The schedule of tests was prepared and conducted by the engineering department of the road under the direction of the chief mechanical officers, there being present during the demonstration several prominent air brake experts of the road, as well as representatives of the two air brake companies.

To what extent the efforts of the Westinghouse Air Brake Company have proven successful is presented in the performance of their 8½″ Cross Compound Pump, a record of which appears later in this article and referred to as the above company's test L 752; being a series of sketches Nos. 1596 to 1603, inclusive, and a number of diagrams plotted from the data found in these sketches. These sketches and diagrams are self-explanatory and clearly show the superiority of the Westinghouse pump, both in economy and capacity.

A very complete apparatus was employed for the tests, making entirely practical a comparison of air delivered, steam consumed, temperature of both free and compressed air as well as the general working of the pumps during the experiments; the apparatus used being arranged as shown on sketch 1603.

A locomotive boiler furnished the steam. The steam passed through a covered receiver which furnished a means for controlling the pressure and also served as a separator. The exhaust steam from the pumps was condensed in a surface condenser and weighed in the barrel arranged as shown. The delivery pipes of the pumps were connected to the constant pressure reservoir No. 3, the overflow from it being alternately measured in the measuring reservoirs Nos. 1 and 2. In arranging the pumps and reservoirs, an effort was made to have the pipe volume of each pump the same. The difference was slight, the Westinghouse pump having the larger volume. Thermometers were inserted in the delivery pipes near the discharge valves of the two pumps, and in reservoir No. 3. Pressure gauges were attached to reservoirs Nos. 1, 2 and 3, and to the steam reservoir. The strokes of the pumps were taken with an ordinary reciprocating counter. The whole apparatus was arranged so that the conditions were almost identical for both pumps, thus avoiding the necessity of making corrections for observations.

The New York No. 5 Duplex Pump has two 8″ x 12″ steam cylinders, and 8″ and 12″ x 12″ air cylinders; the Westinghouse Compound has 8½″ and 14½″ x 12″ steam cylinders and 9″ and 14½″ x 12″ air cylinders. The New York Duplex Pump takes in free air at both air cylinders, one piston resting while the other is in motion; the Westinghouse Compound takes free air at the low pressure air cylinder only, both pistons being in motion at the same time, but moving in opposite directions.

The piston displacement of the compound for one cycle or revolution is 1.43% greater than that of the duplex.

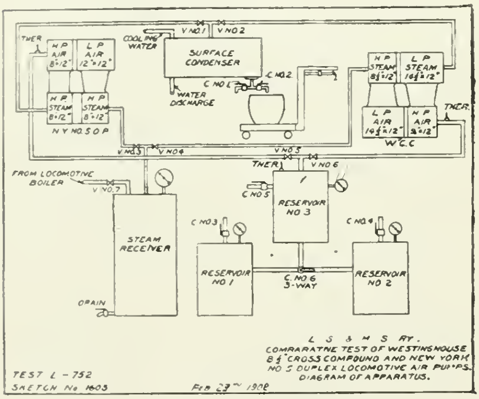
The order in which the tests were made are given in the sketches, the figure preceding the decimal point is the day of the month and the number after the decimal point is the order of the test on that day. The tests have been divided into three classes, as follows:

1st. Efficiency and capacity tests with pumps working against constant pressure; the results of these are shown on sketches Nos. 1596, 1597 and 1598.

2nd. Efficiency and capacity tests with the pumps working against increasing pressure as in charging reservoirs, see sketches Nos. 1599, 1600 and 1601.

3rd. Efficiency and capacity tests with the pumps working against an approximately constant pressure, an orifice in a diphragm being used to approximate the amount of air delivered; these are shown on sketch 1602, which also includes a temperature test, of 20 minutes duration.

In all these tests the pumps were working at full capacity, except in one instance, see sketch 1602, serial number of test 7.29, in which the Westinghouse Cross Compound was made to deliver the same quantity of air as the New York No. 3 by throttling the steam; while this test was being made the steam pressure in the receiver dropped to 156 pounds. In the increasing pressure or charging reservoir tests, the logs of which are shown on sketches 1599, 1600 and 1601, the reservoirs were of slightly difference capacities, due to the difference in piping, viz: 36.3523 cu. ft. for the Westinghouse 8½″ Cross Compound, and 36.3211 cu. ft. for the N. Y. No. 5 Duplex Pump. In calculating the units of comparison, time and steam per 100 cu. ft. of free air, this reservoir difference was considered, but was too small to be noticed. It will be observed that the initial pressure in these tests was 30 pounds in each case, increasing to 70, 100, 130 and 140 lbs., this minimum pressure being selected owing to the excessive pounding of the heads of the New York Duplex, a condition which largely prevailed when the pump was working against low air pressures.



ARRANGEMENT OF APPARATUS.

In this connection it may be said that the Westinghouse Compound worked very quietly, regardless of either high or low air or steam pressures, the tendency to pound being absent even when the throttle was thrown wide open with a high boiler pressure and with little or no air pressure in the charging reservoirs. This is of special importance owing to the "racing" of pumps against low pressure being responsible for a large portion of the failures of pumps of the simple and duplex type.

The comparative diphragm tests, shown on sketch 1602, were made to illustrate the same points brought out in the comparative efficiency and capacity tests, many railroad men being more familiar with this method of comparing air pumps. These tests also serve as a check on the other results when the pumps were working under similar conditions.

As no accurate formula is known for the flow of air through an orifice, the results of this group can hardly be considered comparative. In all of these tests, except 49, the pumps were working to their maximum capacity, and although it is true that both were discharging through the same size of orifice, the higher pressure maintained by the Westinghouse pump throws additional work on it and this is not fully shown by the amount of air discharged. Test 7.29, sketch 1602, was made, however, in an effort to make the work of the Westinghouse equal to that of the New York pump in test 7.22, and to compare the steam consumption. The Westinghouse pump was, therefore, throttled so that both pumps maintained approximately the same air pressure while discharging through the same orifice, with the result that the New York pump used 110% more steam than the Westinghouse. This test also brings out the fact that to do the same work the Westinghouse pump required 136 pounds boiler pressure, whereas the New York required 200 pounds.

In the temperature tests, shown on sketch 1602, both pumps were run to their maximum capacity, the compound pumping against a 19-64″ orifice, the duplex supplying a 17-64″ orifice, resulting in a decidedly higher temperature for the former than would have been the case had each pump supplied the same volume of air. The results of the tests, however, have been plotted in the form of curves and are shown on one of the diagrams accompanying the sketches.

The temperature of the Westinghouse Compound Pump was much lower than that of the New York Duplex Pump for an equal interval between tests; this and the tendency of the New York pump to heat rapidly made it difficult to start it at a low temperature which could only have been done by long delays between tests. To compensate for this, the Compound was run a considerable time before starting the temperature tests in order to get its temperature equal to that of the New York pump.

It was made evident by these tests that when Mr. George Westinghouse designed and patented a compound air pump in 1873 he foresaw, even while the air brake was yet in its infancy, that at some remote period steam economy must become a ruling consideration in locomotive air pump operation, and to judge from the strenuous efforts of railways in the direction of such economy it would seem that the time has now arrived.

Serial Number of Test	Average of 20.1 & 20.3	Average of 20.2 & 20.4	Per cent. in favor of W. C. C.	6.3	6.4	Per cent. in favor of W. C. C.	6.5	6.6	Per cent. in favor of W. C. C.	6.7	6.8	Per cent. in favor of W. C. C.
Style of Pump	W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.	
Steam Pressure	200	200		200	200		200	200		200	200	
Constant Air Pressure Pumped Against	140	140		130	130		100	100		70	70	
Cubic Feet Free Air Pumped	666.5	666.5		616.8	616.8		625.4	625.4		534.8	534.8	
Duration of Test—Minutes and Seconds	5-46.4	8-52.1		4-41.8	6-35.6		4-07.6	5-24.2		3-11	3-52.2	
Cubic Feet Pure Air Pumped per Minute	115.5	75.2	53.6	131.0	93.6	40.1	151.6	115.7	31.0	168.0	138.2	21.6
Cycles per Minute	61.8	53.8		65.3	58.4		74.2	66 1		81.4	72.9	
Weight of Steam Used—Pounds	143.5	317.6	121.3	121.3	249.0	105.4	116.0	207.8	79.1	94.8	164.5	74.0
Steam per 100 Cubic Feet Free Air—Pounds	21.5	47.7	121.3	19.7	40.4		18.6	33.2		17.7	30.8	
Cubic Feet Free Air per pound Steam	4.64	2.10	121.3	5.09	2.48		5.39	3.01		5.65	3.25	
Volumetric Efficiency—Per cent	82.1	62.2	31.9	88.2	71.4	23.6	89.7	78.0	15.0	90.7	84.5	7.3
Temperature Deg. Fahr. At Pump Discharge Initial	313	355		280	378		330	380		320	400	
Temperature Deg. Fahr. At Pump Discharge Final	422	480		390	500		400	497		380	470	
Temperature Deg. Fahr. In first of 3 Connected Reservoirs Initial	154	158		161	179		190	199		200	209	
Temperature Deg. Fahr. In first of 3 Connected Reservoirs Final	184	184		182	201		211	224		218	298	
Atmosphere	73	75		70	70		70	70		70	71	

L. S. & M. S. RY.
Comparative test of Westinghouse 8½″
Cross Compound and New York No. 5
Duplex Locomotive Air Pumps.
Pumps working against constant Pressure

Test L—752
Sketch No. 1596

Feb. 23, 1906

Serial Number of Test	6.15	6.16	Per cent. in favor of W. C. C.	6.17	6.18	Per cent. in favor of W. C. C.	6.19	6.20	Per cent. in favor of W. C. C.
Style of Pump	W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.	
Steam Pressure	150	150		150	150		150	150	
Constant Air Pressure Pumped Against	120	120		100	100		70	70	
Cubic Feet Free Air Pumped	567.8	567.8		625.4	625.4		534.8	534.8	
Duration of Test—Min. and Sec	6-37.2	9-28	43.0	5-38.4	7-51.1	39.3	4-02.2	5-02.1	24.9
Cubic Feet Free Air Pumped per Min	85.8	60.0	43.0	110.9	79.6	39.3	132.5	106.1	24.9
Cycles per Minute	44.1	39.7		54.4	48.8		63.2	58.3	
Weight of Steam Used—Pounds	105.5	220.8	109.3	102.8	208.5	102.9	81.5	148.5	82.2
Steam per 100 cu. ft. Free Air—Pounds	18.6	38.9	109.3	16.4	33 3	102.9	15.2	27.8	82.2
Cubic Free Air per pound Steam	5.38	2.57	109.3	6.09	3.00	102.9	6.56	3.60	82.2
Volumetric Efficiency—Per cent	85.4	67.3	27.0	89.4	72.8	23.0	92.2	81 1	13.7
Temperature. Deg. Fahr. At Pump Discharge Initial	270	317		270	350		320	300	
Temperature. Deg. Fahr. At Pump Discharge Final	360	440		370	450		360	400	
Temperature. Deg. Fahr. In first of three connected Reservoirs Initial	174	175		180	182		184	186	
Temperature. Deg. Fahr. In first of three connected Reservoirs Final	184	185		186	190		194	196	
Temperature. Deg. Fahr. Atmosphere	78	78		76	78		77	77	

L. S. & M. S. RY.
Comparative test of Westinghouse 8½″
Cross Compound and New York No. 5
Duplex Locomotive Air Pumps
Pumps working against constant pressure.

Test L—752
Sketch No. 1598

Feb. 23, 1906

Serial Number of Test		7.1	7.5	Per cent. in favor of W. C. C.	7.2	7.6	Per cent. in favor of W. C. C.	7.3	7.7	Per cent. in favor of W. C. C.	7.4	7.8	Per cent. in favor of W. C. C.,
Style of Pump		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.	
Steam Pressure		200	200		200	200		200	200		200	200	
Initial Air Pressure		30	30		30	30		30	30		30	30	
Final Air Pressure		70	70		100	100		130	130		140	140	
Cubic Feet Free Air Pumped		98.9	98.8		173.1	173.0		247.3	247.1		272.0	271.8	
Duration of Test—Minutes and Seconds		0–39 8	0–43.2		1–12.4	1–22.4		1–47.6	2–10.2		1–59.2	2–29.6	
Total Cycles		55	55		98	100		139	149		150	168	
Weight of Steam Used—Pounds		21	31.8		36.3	57.3		51.8	92		57.5	102.3	
Required to compress 100 cu. ft. Free Air From Initial to Final Pressure.	Time Sec.	40 2	43.7	8.6	41.8	47.6	13.9	43.5	52.7	21.1	43.8	55.0	25.6
	Steam Pounds.	21.2	32.1	51 4	20.9	33.1	58.1	20.9	37.2	78.0	21.1	37.6	78.0
Temperature Deg. Fahr. At Pump Discharge	Initial	208	206		242	238		269	280		310	320	
	Final.	236	252		286	304		324	370		360	410	
In first of 3 Connected Reservoirs	Initial	100	130		106	132		122	140		134	150	
	Final.	103	138		120	140		130	156		150	168	
Atmosphere		69	71		70	73		70	73		70	73	

L. S. & M. S RY.
Comparative test of Westinghouse 8½″
Cross Compound and New York No. 5
Duplex Locomotive Air Pumps.
Pumps working against increasing pressure
as in charging Reservoirs.

Test L–752
Sketch No. 1599

Feb. 23, 1906.

D	17/64″	19/64″	23/64″
T	.034″	.056″	.0615″

Serial Number of Test		7.21	7.22	7.29	7.23	7.24	7.25	7.26
Style of Pump		W.C.C.	N. Y. 5 D.P.	W.C.C.	W.C.C.	N. Y, 5 D.P.	W.C.C.	N. Y. 5 D P.
Orifice in Diaphragm	Diameter—In.	17/64″	17/64″	17/64″	19/64″	19/64″	23/64″	23/64″
	Area—Sq. In.	.055420	.055420	.055420	.069227	.069227	.101434	.101434
Steam Pressure		200	200	156	200	200	200	200
Initial Air Pressure		118	100	100	100	88	70	63
Final Air Pressure		120	102	100	104	88	73	63
Duration of Test—Min.		2	2	2	2	2	2	2
Cycles per Min.		67	65.5	57.5	73.5	69.5	81.5	75.0
Steam Used per Min.—Lbs.		25.6	40.6	19.3	27.9	43.8	29.4	40.5
Temperat're Deg. Fahr. At Pump Discharge	Initial	242	310	400	300	360	301	410
	Final.	296	360	417	340	420	346	430
In Reservoir	Initial	111	126	234	140	163	170	180
	Final.	122	137	236	153	172	179	190
Atmosphere		69	72	69	73	70	72	72

L. S. & M. S. RY.
Comparative test of Westinghouse 8½″
Cross Compound and New York No. 5
Duplex Locomotive Air Pumps.
Orifice and Temperature Tests.

Test L—752
Sketch No. 1602

Feb. 23, 1906

Serial Number of Test	6.9	6.10	Per cent. in favor of W. C. C.	6.11	6.12	Per cent. in favor of W. C. C.	6.13	6.14	Per cent. in favor of W. C. C.
Style of Pump	W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C	N. Y. 5 D.P.	
Steam Pressure	175	175		175	175		175	175	
Constant Air Pressure Pumped Against	130	130		100	100		70	70	
Cubic Feet Free Air Pumped	616.8	616.8		625.4	625.4		534.8	534.8	
Duration of Test—Min. and Sec	5–43.2	8–32	49.2	4–43.4	6–14.2	32.1	3–31.6	4–22.2	23.9
Cubic Feet Free Air Pumped per Min	107.9	72.3	49.2	132.4	100.3	32.1	151.6	122.4	23.9
Cycles per Minute	55.1	47.1		64.8	59.2		73.4	65.9	
Weight of Steam Used—Pounds	124.5	251.0	101.6	110.8	206.3	86.2	85.8	155.5	81.4
Steam per 100 cu. ft. Free Air—Pounds	20.2	40.7	101.6	17.7	33.0	86.2	16.0	29.1	81.4
Cubic Feet Free Air per Pound Steam	4.96	2.46	101.6	5.65	3.03	86.2	6.24	3.44	81.4
Volumetric Efficiency—Per cent	86.0	68.4	25.8	89.6	75.5	18.7	90.7	82.8	9.6
Temperature, Deg. Fahr. At Pump Discharge Initial	320	320		298	370		300	360	
At Pump Discharge Final..	400	470		384	470		368	440	
In first of three connected Reservoirs. Initial	140	168		172	185		196	194	
In first of three connected Reservoirs. Final..	169	190		194	205		206	206	
Atmosphere	75	76		74	78		78	79	

Pumps working against constant pressure.

Serial Number of Test	7.9	7.12	Per cent. in favor of W. C. C.	7.10	7.13	Per cent. in favor of W. C. C.	7.11	7.14	Per cent. in favor of W. C. C.
Style of Pump	W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.	
Steam Pressure	175	175		175	175		175	175	
Initial Air Pressure	30	30		30	30		30	30	
Final Air Pressure	70	70		100	100		130	130	
Cubic Feet Free Air Pumped	98.9	98.8		173.1	173.0		247.3	247.3	
Duration of Test—Min and Sec	0–41.8	0–48.6		1–06.6	1–32.8		1–56	2–32	
Total Cycles	55	56		94	103		134	155	
Weight of Steam Used—Pounds	18.5	22.8		32	56		40.8	86	
Required to compress 100 cu. ft. Free Air from Initial to Final Pressure Time—Sec	42.3	49.2	16.4	44.3	53.7	21.4	46.9	61.5	31.1
Required to compress 100 cu. ft. Free Air from Initial to Final Pressure Steam—Pounds	18.7	23.0	23.1	18.5	32.4	75.1	16.5	34.8	111.2
Temperature, Deg. Fahr. At Pump Discharge Initial	234	258		276	282		298	308	
At Pump Discharge Final..	258	300		310	362		344	385	
In first of three connected Reservoirs Initial	154	163		154	160		161	162	
In first of three connected Reservoirs Final..	160	168		165	199		176	174	
Atmosphere	74	74		73	73		75	75	

Pumps working against increasing pressure
as in charging Reservoirs.

Special Number of Test	7.15	7.18	Per cent. in favor of W. C. C.	8.16	7.19	Per cent. in favor of W. C. C.	7.17	7.20	Per cent. in favor of W. C. C.
Style of Pump	W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P.		W.C.C.	N. Y. 5 D.P	
Steam Pressure	150	150		150	150		150	150	
Initial Air Pressure	30	30		30	30		30	30	
Final Air Pressure	70	70		100	100		130	130	
Cubic Feet Free Air Pumped	98.9	98.8		173 1	173.0		247.3	247.1	
Duration of Test—Min. and Sec	0–46	0–55		1–26.4	1–47		2–21	3–08	
Total Cycles	52	57		95	98		137	154	
Weight of Steam Used—Pounds	15	29		29.5	52.8		44	85 3	
Required to compress 100 cu. ft. Free Air from Initial to Final Pressure Time—Sec	46.5	55.6	19 7	49.9	61.9	24.0	57 0	76 1	33 4
Required to compress 100 cu. ft. Free Air from Initial to Final Pressure Steam—Pounds	15.2	29.3	93.5	17.0	30.5	79 0	17 8	34 5	93 9
Temperature, Deg. Fahr. At Pump Discharge Initial	240	240		255	275		302	350	
At Pump Discharge Final.	264	280		293	330		344	400	
In first of three conected Reservoirs Initial	165	162		160	162		159	174	
In first of three conected Reservoirs Final.	170	168		172	170		175	190	
Atmosphere	76	78		75	78		77	78	

Pumps working against increasing pressure
as in charging Reservoirs.

THE Traylor Engineering Co., and the Traylor Manufacturing and Construction Co., have been consolidated into one corporation, under the name of the Traylor Engineering Company.

The consolidation was the result of the rapid increase of the business of the Traylor Engineering Co., which made it desirable to combine the two concerns in order to simplify and expedite the conduct of their business. Under the old arrangement the Traylor Engineering Company was the active concern dealing with the public, while the Traylor Manufacturing and Construction Company owned the works at Allentown, Pa., and did the manufacruing under contract for the other. Both concerns belonged to the same stockholders. They were organized under the laws of New Jersey. The new corporation is organized under the laws of New York. It takes over all the assets and business of the older corporations and assumes their liabilities. The two New Jersey corporations have been dissolved. The change in incorporation makes no change in the business to simplify its internal conduct. The public will continue to find the Traylor Engineering Co., at its offices in the Engineering Building, 118 Liberty street, New York, and with its constantly increasing staff of experts always ready to give advice on Mining, Metallurgical, Cement-making, Fuel Briquetting or Rock Crushing matters.

The Officers of the corporation are: President and Treasurer, Samuel W. Traylor; Vice-president, Bruce W. Traylor; Assistant Treasurer, Frank W. Hopkins; Secretary, Joseph S. Buhler.

The capital stock authorized is $600,000. Of this amount $500,000 is issued to pay for the properties and business taken over, and the balance remains in the treasury for future needs.

A NEW plant will shortly be constructed at Plainfield, N. J., for the Vacuum Cleaner Company, 427 Fifth Avenue, New York. The company proposes to manufacture its wagons, vacuum pumps and other carpet and rug cleaning machinery. Dodge & Morrison, of 82 Wall street, are the architects of the proposed plant and they will also have charge of the engineering details. The plant will consist of a main factory building of mill construction, 60x170 feet, two stories in height. The main building will contain a machine shop, general assembly department, paint and wood-working department, etc. There will be a brass foundry, 20 x 50 feet; power house, 42 x 42 feet; pattern building 15 x 20 feet, and pattern storage building, 15 x 20 feet. The machinery details have not been worked out as yet, with the exception that it has been decided to install about 200 horse-power of boilers and most of the machinery equipment of the plant will be electrically operated. Besides purchasing a complete brass foundry equipment the company will require a rather general assortment of machine tools and some woodworking equipment. These details are all in the hands of Dodge & Morrison, who will also let the contract for the construction of the building. It is proposed to give out that work very shortly and the plant will be built as soon as possible. The company has a desirable location adjacent to the tracks of the Central Railroad of New Jersey and arrangements will be made to construct a spur from the main line into the company's property and through the erecting yard, in which will be built an erecting platform, in order to facilitate the shipping of the firm's product. The company has purchased considerable property to allow for enlarging its plant when there is necessity for it.

A HUGE UNDERTAKING SUCCESSFULLY COMPLETED.

The great new Government Custom House opposite the historic Bowling Green has just received its final treatment at the hands of the American Diamond Blast Co.

Five months of labor resulted in a beautiful looking building. The stone of which it was built was carefully tooled and finished, but to bring out its true color the company's sand blast treatment was used with wonderful effect. Three hundred and sixty thousand square feet were thoroughly worked over, much time being devoted to the ornate carvings, which required the most careful manipulation.

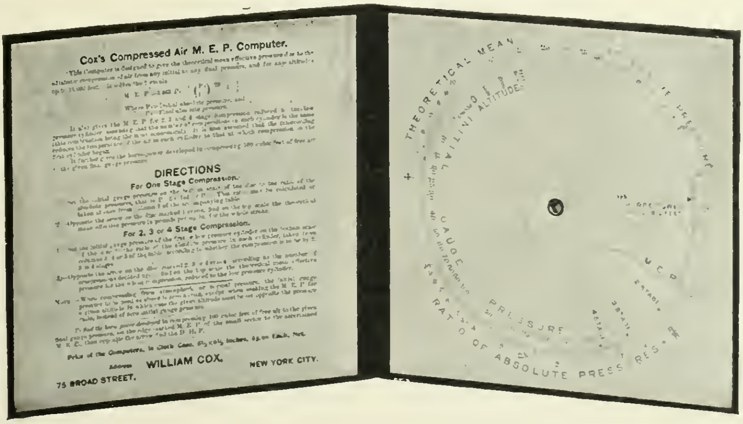
Other buildings in the neighborhood which have been restored to their original purity of exterior are the Empire Building, Banking House of J. P. Morgan & Co., and the County Court House.

A new corporation, known as the Pittsburgh Pneumatic Company, with a capital of $250,000 has been formed with Pittsburgh men behind it and will shortly build and operate a large plant for the manufacture of pneumatic tools. It is considered that the establishment of this new industry in Pittsburgh is of unusual interest, because up to the present time there are no plants making pneumatic machines in the form of riveters and drills in the Pittsburgh district, though there are few markets of greater importance for these machines than this section.

The new company has elected officers, with Frank M. Faber, president; Charles H. Johnson, treasurer, and Charles C. Murray, secretary. The officers are practical pneumatic tool men. When the plant is in running order it will give employment to a large number of skilled mechanics.

A NEW COMPRESSED AIR COMPUTER.

William Cox, 75 Broad street, New York, has recently devised a very useful addition to the list of computers which he manufactures. The accompanying illustration shows the general style of Mr. Cox's computers, which now number over a hundred, each being designed to solve some special formula relating to the flow of air, gas and water. His latest computer, however, is designed to solve the formula



COX COMPRESSED AIR COMPUTERS.

$$\text{M. E. P.} = 3.463\ P_1 \left[\left(\frac{P_2}{P_1} \right)^{.29} - 1 \right]$$

in which P_1 = the initial absolute pressure; P_2 = final absolute pressure. This being the formula for the theoretical mean effective pressure in single-stage compression.

Accompanying the instrument is a table of ratios of compression from atmosphere to 2,000 lbs., the table giving the ratios for single-stage compression and the ratio for each cylinder for 2, 3 and 4-stage compression.

The mean effective pressure once found, the horse-power required to compress 100 cu. ft. of free air is determined by setting the M. E. P. edge of the sector to the ascertained mean pressure when; against the horse-power arrow, will be found the horse-power required.

Among the latest additions to Mr. Cox's list of computers might be mentioned computers for solving the horse-power transmitted by belts, computers for paper friction pulleys, and for testing electrical meters.

A SPECIAL caisson has been sunk at the foot of Fifteenth street, Jersey City, in the construction of a connection between the Hudson Company's tunnels from Morton street, New York, under the North River to Jersey City, with branches to the terminals of the Erie and of the Dalaware, Lackawanna & Western Railroads. This caisson is near the working shaft for the main tunnels, and was sunk to facilitate the building of the divergent tunnels at their point of intersection. The single-track tubes of the connections are located to clear each other vertically and as the tunnel structure at this point could not be readily built by ordinary tunneling methods, special provision has been made for it by the use of a pneumatic caisson sunk 80 ft. or more through earth and water into the rock. The caisson, which is five-sided and is approximately 100 ft. long and half as wide, is constructed of reinforced concrete, affording a large estimated economy over the use of steel or timber. It consists of a massive concrete block containing a working chamber and an upper chamber separate from the latter. The working chamber eventually forms one section of the low-level tunnel; the upper chamber forms the corresponding section of the upper-level tunnel. The lower chamber was provided with an air-tight lining cemented in position to prevent the leakage of air pressure through the porous concrete.

PRACTICAL ITEMS for PRACTICAL MEN.

To the Editor of COMPRESSED AIR:

Dear Sir.—I, believing you are in search of information in relation to the practical side of compressed air, will in the following few lines try to give some of my experiences in repairing pneumatic stone tools.

If the instructions given by every manufacturer of stone carving tools were followed closely, their repair bills would be a great deal less. Sometimes in my experience we have had to cut away the outer casing on carving tools just because the user has neglected to soak the tool in coal oil over night and has used instead of a pneumatic oil any oil which was handy. The ports become clogged up and no amount of soaking will dislodge the grit from these ports. This clogging does not take place immediately, but goes on gradually and, you might say, is not noticeable until perhaps a new tool is started, then the other is noticed not to be working up to standard. The redress is the repair shop. Now, again, this neglect to clean the tool will cause fine particles of foreign matter in the air to collect in the ports, these particles being so fine that, were the tools clean, they would go through without lodging; but when collected together they are dangerous, especially when the user realizes that he has been starving the tool and then gives it a large dose of lubricating oil without taking it apart and cleaning it. This is the time that these small particles of grit get in their work, causing the tool to wear loose sooner than it should. This is only one small word of advice to the users of pneumatic tools, but if followed up they will find that this neglect is costing them more than they think. JOHN GRACE.

HEATING RAILROAD SWITCHES.

The Scientific American directs attention to a new method of heating railroad switches. The greatest difficulty that railroads have to contend with in winter time is the blocking of switches with snow and ice. When the snow is wet and freezes, the difficulty increases. To overcome these serious conditions attempts have been made to heat the switches with electricity, but that has proved expensive and dangerous. Steam-heated switches have also met with but little success, due to the danger of condensation and subsequent freezing, which would entirely block the steam pipes. A new system has been developed in which oil is used in place of steam—hot oil of a special quality circulated through pipes placed between the ties. The advantage of oil over steam is that it retains the heat better, and will not chill to 25 degrees below zero. Furthermore, if it should chill, it will not expand and burst the pipes as water would when freezing. A test of the system on the Boston and Main Railroad is said to have been very satisfactory.

REVERSIBLE STEAM TURBINE.

A recent issue of the *Mechanical Engineer* gives a description of a reversible steam turbine, in which the reversal is effected by two sets of vanes set on concentric circles with reference to the rotating shaft, one set of veins being so constructed as to move the shaft forward and the other so as to move it in the reverse direction. Leakage of steam from the various passages is prevented by means of light steel stampings used to cover annular openings in the stationary element into which it is admitted and, by its escaping through the narrow openings under the steel stampings, has its velocity so increased that leakage of live steam in the reverse direction is prevented.

SUPERHEATED STEAM.

The following statements regarding the use of superheated steam can be readily derived from the principles of its action:

First, superheated steam is more effective in saving with simple than with compound or multiple-stage engines, or conversely.

Second, with superheated steam there is less need for multiple-stage engines beyond the compound.

Third, superheated steam, in order to realize its full possibilities, should be carried in superheat to a point which will insure a superheated vapor throughout the admission and expansion stages of the cycle. With high-expansion ratios this will be difficult to realize completely, but the more nearly this condition is fulfilled the more effective the action in reducing the loss by cylinder condensation.

Fourth, superheating carried beyond this point will be of little additional value and will scarcely justify the additional expense.

Fifth, superheating should be carried to a higher degree as the expansion ratio is higher, and therefore to a higher degree for compound and multiple-stage engines than for a simple engine.

Sixth, a moderate degree of superheat is of comparatively small value, for the reason that the steam is quickly reduced by the operation of expansion, or even before, to the saturated or moist condition, with the resulting increase in the loss by the activity of the secondary or "cast-iron" cycle. While there is no sharp line, and while some gain will be derived from low degrees of superheat, such gains will hardly begin to be significant until a superheat of some 40° or 50° is realized, and from such point upward the gain will be continuous for further superheat until the approach of the limit mentioned under the third conclusion.

Seventh, superheating may be carried out in stages between the operations of expansion, as in the receiver of a compound engine, and in such case the sum of the partial superheats may be made less than when the entire operation is carried out at once, as in the usual arrangement.—*Engineering Record.*

COST OF POOR LUBRICATION.

The Southern Engineer in a very excellent article on "Cylinder Lubrication" mentions a certain engine builder who was an advocate of the practice of using no oil on the valves and cylinders of engines. He installed an engine in a neighboring plant, taking care that no oil or grease be used in tapping or boring, claiming that if there was never any oil or grease used in the pores of the iron, the condensation of steam would adher to the metal. Consequently no holes were drilled in the steam pipe of the engine whereby oil could be introduced. The engine was in use for a number of years, and during this time the cylinder head was removed frequently for examination. At no time could any perceptible wear be detected by the use of calipers and straight edge, either in the valve or the cylinder.

This test should convince any fair-minded person that it is not absolutely necessary to use a lubricant in a properly constructed engine. To offset this very desirable showing is the fact that it was shown from indicator cards that the coal consumption was enormous. After several years run under the above conditions a lubricator was attached to the engine. Since then it has shown a saving of 1-3 pounds of coal per horse power per hour.

Crude oil, according to the results of recent experfments, has a fuel value per pound equal to that of 2,785 pounds of California coal. The oil weighs 7.6 pounds per gallon, so that 94½ gallons equal a ton of the coal specified.

CHIPPINGS.

WHAT HOT AIR COSTS BELGIUM

A Belgian statistician has just made the discovery that the sittings of the Belgian Parliament cost the nation $1,457 an hour, or more than $24.00 a minute. He deduces that most of this money is lost to the nation because of useless loss of time expended in the making of the laws, long speeches which never carry conviction into the enemy's camp, interruptions and applause.

A centrifugal pump, to operate at a high efficiency, is necessarily limited to special purposes. With refined machines, 80 per cent. of useful effect is attainable, but one that will utilize 60 per cent. of the power applied is likely to be the best machine to buy. The efficiency attainable in various uses is from 40 to 80 per cent. being lowest in dredging machines, but the strange feature of the matter is the constant inquiry respecting efficiency. A customer will go to a maker or dealer in displacement pumps and purchase one to operate at an efficiency of 25 to 35 per cent. and never make an inquiry or ask a guaranty of effect.

HAPPY MEXICO.

The most remarkable mountain of iron in the world is in the State of Durango, Mexico; it is 4,800 feet long by 1,100 feet wide and 640 feet high. Engineers estimate that it contains between 500,000,000 and 600,000,000 tons of ore above the surface, and it is known that the deposit extends under ground for a radius of three or four miles in all directions. The ore is high grade, containing roughly 70 per cent. iron and only about 0.03 per cent. phosphorus. People who dig wells or sink shafts for any purpose in the vicinity of Durango strike iron, and there is a theory that 75 to 100 feet below the surface is a solid stratum of iron covering an area as big as a county. There is enough iron in sight to last the entire world for a century.

SUBWAY COOLING PLANTS.

An experimental plant for cooling the air in the Brooklyn Bridge station of the New York Subway is under construction. It is expected that it will be in operation before the end of August, and, if it is successful, similar plants will be built at other stations. The principle of the plants, there being two of them—one on the uptown and one on the downtown side

—is that of cooling air by passing it over cool water forced through large coils. There are fans to draw the fresh air in from the street, and also to force it into the station after it has been cooled. The water used in cooling the air is obtained from four driven wells, two at the northern end of each platform. There is a pump capable of drawing 450 gallons of water a minute connected with each pair of wells. The water, which comes out at a temperature of from 52 to 62 degrees Fahr., is conducted to two large coils of pipes, over which the air passes. Each coil has a surface sufficient to cool 75,000 cubic feet of air a minute. From the coolers the air will be distributed to the station through large galvanized iron ducts running over the four platforms. It is estimated that the temperature in stations will be lowered at least fifteen degrees. Several other cooling experiments will be tried this summer, and by another season it is hoped to have all the stations equipped with the device that proves the most successful. Work is also going on now in making the openings between the stations, in which automatic valves are to be installed.

In discussing the widening use of compressed air in shop and foundry, Professor J. J. Flather, in "Cassier's Magazine" says:

"In most cases no attempt has been made to use the air efficiently; its great convenience and the economy produced by its displacement of hand labor have until recently been accepted as sufficient, and greater economies have not been sought.

"In the matter of compression we still occasionally find very inefficient pumps in use, but manufacturers generally have learned that it pays to use high grade, economical compressors. The greatest loss is that in the air motor itself. In a large number of cases it is impracticable, or, at most, inconvenient to employ re-heaters, and we find very generally that the air is used at normal temperature for the various purposes to which it is applied.

"To obtain the most satisfactory results, the air must be used expansively; but usually where the demand for power is intermittent, no attempt has been made to reheat the air, and as a result the combined efficiency of compressor and motor is quite low, varying in general from 20 to 50 per cent. While low working pressures are more efficient than high, the use of such pressures would demand larger and heavier motors and other apparatus which is undesirable. The advantages of higher pressures in reducing cost of transmission are also well recognized, and the present tendency is to use air at 100 to 150 pounds instead of the 60 or 70 pounds of a few years ago.

"By reheating the air to a temperature of about 300 degrees F., which may often be accomplished at small expense, the efficiency is greatly increased; in some cases the increase has been found to be as high as 80 per cent. While the lower pressures are yet more efficient, the loss due to higher compression is not serious.

"If air be used without expansion, there is a material loss in efficiency; but, on the other hand, if it be used expansively without reheating, trouble may be experienced from drop in temperature below the freezing point. With moisture present, this drop will cause the formation of ice, which may clog the passages if proper precautions are not taken to prevent it. The low temperature will not in itself cause trouble; if, therefore, the moisture which the compressed air holds in suspension be allowed to settle in a receiving tank, placed near the motor or other air apparatus, and frequently drained, trouble from this cause will be largely avoided.

"While it may be impracticable to reheat the air in certain cases, yet there are many situations where a study of means to overcome the losses referred to would result in marked economies."

A PNEUMATIC TIDAL GAUGE.

Owing to the fact that no fewer than 522 dangerous rocks and shoals, twenty-six of which "were discovered by vessels striking on them," were reported to the British Admiralty in 1905, the Admiralty has been experimenting with an instrument calculated to be of much service in localities where a shelving and shifting beach necessitates a tide pole or tide watchers.

The instrument is called the manometer. This is described as a pneumatic tide gauge, fitted with a reservoir of compressed air, the pressure due to the height of the tide being balanced by the recorded pressure of a continuous current of air passing through the apparatus and slowly escaping through rubber tubing at a fixed point under water.

The Admiralty report on the subject states: "It is a remarkable fact that the number of rocks and shoals discovered each year steadily increases; while such continues to be the case the need is obvious for more numerous and more detailed hydrographic surveys."

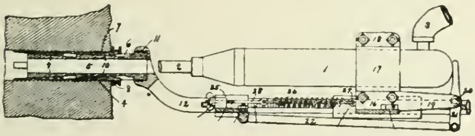
U. S. PATENTS
ESPECIALLY PREPARED FOR
COMPRESSED AIR

823,281. TRAIN-STOPPING APPARATUS. John H. King, Cincinnati, Ohio. Filed April 8, 1905. Serial No. 254,473.

823,315. AIR-SUPPLY APPARATUS FOR AIR-BRAKES. Ernest B. Allen, Louisville, Ky. Filed Feb. 13, 1906. Serial No. 300,852.

Claim.—An air-supply apparatus for air-brakes, comprising a main reservoir for compressed air, a single-acting pump mounted on the truck and having at one end a suction-valve opening inwardly from the atmosphere and an outlet-valve with pipe leading therefrom to the reservoir, a cam fixed to the car-axle, a piston in the pump-cylinder with rod and shoe having a range of adjustment to or from the cam, a slide-rod arranged beside and outside the pump-cylinder and having an arm connected to the piston-rod and shoes and means for adjusting said slide-rod and shoe to contact with the actuating-cam substantially as described.

824,250. PNEUMATIC-TOOL HOLDER. Ambrose E. Knapp, Seattle, Wash. Filed Nov. 27, 1905. Serial No. 289,232.



Claim.—In a tool-holder, the combination of a sleeve having a square hole and dovetail slots longitudianlly-extending engaging members mounted in said slots and provided with teeth on their outer sides and a plurality of inclines on their inner sides, said sleeves having inclines corresponding thereto, a spring-ring adapted to hold said engaging means in position, a tool-holder comprising parallel rods secured to one end of said sleeve, and a tool-carrier slidably mounted on said rods.

824,351. STONE-QUARRYING MACHINE. Emerson T. Morris, Derwent, Ohio, assignor of one-half to George H. Morris, Derwent, Ohio. Filed March 8, 1905. Serial No. 249,120.

Claim.—In a stone-quarrying machine, the combination of a stationary structure, a main framework supported thereby, means for imparting a rectilinear reciprocating movement thereto, a cutter mounted upon said framework, means for reciprocating the cutter at a right angle to the plane of movement of the main framework, a second framework, operating mechanism carried by said second framework, a feed mechanism, connecting means between said operating mechanism and said cutter and freed mechanism, a crank connection between said second framework and the stationary structure and slidable with reference to the latter, whereby provision is had for proper feed of the cutter, and a telescoping guide connection between the main framework and said stationary structure.

824,585. PNEUMATIC GRAIN-MOVING APPARATUS. Julius C. Reith and John H. Chamberlain, Chicago, Ill. Filed June 5, 1905. Serial No. 263,767.

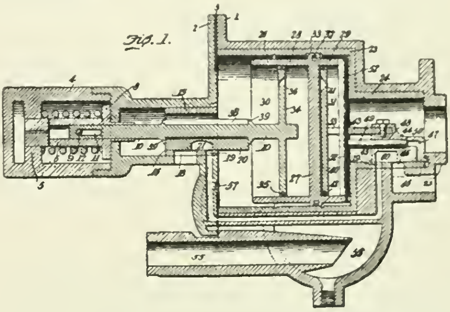
824,681. PRESSURE-REGULATOR. Frank M. Ashley, Brooklyn, N. Y., assignor of one-half to Albert T. Scharps, New York, N. Y. Filed Feb. 19, 1902. Serial No. 94,727.

824,683. PNEUMATIC CARPET-CLEANER. John L. Chesnutt, Chicago, Ill., assignor to Thomas G. Orwig, Des Moines, Iowa. Filed Jan. 2, 1903. ,Renewed Nov. 29, 1905. Serial No. 289,666.

Claim.—In a pneumatic carpet-cleaner, an open-bottomed case having vertical grooves in the inside faces of its ends and an air-distributer having fixed journals on its ends adapted to traverse said grooves to change the inclination of the air-distributer, combined to operate as set forth for the purposes stated.

824,604. PNEUMATIC TIRE. Charles R. Twitchell, Los Angeles, Cal., assignor of one-half to James M. Brennan, Los Angeles, Cal. Filed Sept. 25, 1905. Serial No. 280,029.

824,712. AIR-BRAKE MECHANISM. John Dillander, San Francisco, Cal. Filed July 6, 1904. Serial No. 215,482.

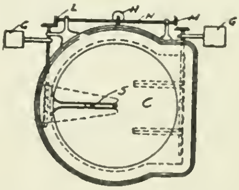


Claim.—In air-brake mechanism, a main valve, a graduating-valve, and independent pistons for moving said valves successively on a graduated application, and simultaneously through the entire stroke on an emergency application.

824,718. FLUID-PRESSURE BRAKE. James A. Hicks and Frank H. Hill, Atlanta, Ga. Filed July 27, 1905. Serial No. 271,491.

Claim.—In a fluid-pressure brake system, means for directing air from the main brake-pipe directly into the brake-cylinder independently of the triple valve, and automatic means controlled by auxiliary pressurue for establishing and cutting off the flow of air from the brake-pipe to the brake-cylinder.

824,876. AIR-LOCK FOR CAISSONS. Samuel Mattson, New York, and William M. Torrance, Yonkers, N. Y. Filed Oct. 27, 1905. Serial No. 284,609.



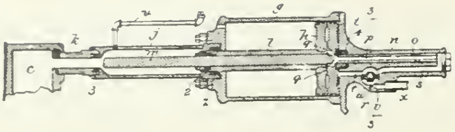
Claim.—In an air-lock the combination with one of the openings thereto, of a main door constructed to close entirely across the opening and provided with a rope-passing slot extending from one edge to the middle part of the door with respect to the opening, and a slot-closing door hinged from the side of the lock opposite the side from which the main door is hinged, and constructed to close the slot when the main door is closed.

825,077. FLUID-PRESSURE BRAKE. William H. Sauvage, New York, N. Y., assignor to Sauvage Safety Brake Company, a Corporation of New Jersey. Filed Dec 26, 1905. Serial No. 293,160.

825,113. SUPPORT FOR COAL-DRILLS. William H. Clarkson, Edwards Station, Ill., assignor to Eluide J. Clarkson, Edwards Station, Ill. Filed Jan. 30, 1905. Serial No. 243,299.

825,160. PROCESS OF AND APPARATUS FOR BLOWING HOLLOW GLASS ARTICLES. Paul T. Sievert, Dresden, Germany. Filed Jan. 7, 1905. Serial No. 240,003.

825,164. ELASTIC-FLUID TURBINE. Edwin F Taylor, Wyncote, Pa. Filed Oct. 29, 1904. Serial No. 230,536.

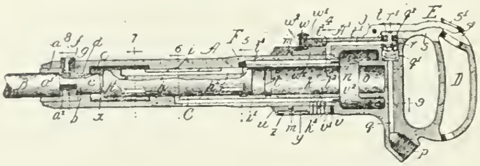


825,301. HYDROPNEUMATIC PRESS. Edwin D. Coddington, North Milwaukee, Wis. Filed Aug. 5, 1903. Serial No. 168,250.

Claim.—In a hydropneumatic press the combination with a ram and a cylinder therefor, of a cylinder provided with two independently-movable pistons, and with a tubular extension having larger and smaller bores, and plungers attached to said pistons and fitted one within the other to work in the smaller and larger bores respectively of said cylinder extension, substantially as described.

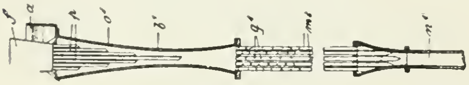
825,592. DEVICE FOR INFLATING PNEUMATIC TIRES. Alfred T. Fisher, Brooklyn, N. Y. Filed Dec. 5, 1904. Renewed June 14, 1906. Serial No. 321,668.

825,669. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill., assignor to International Tool Company of Chicago, a Corporation of Illinois. Filed March 20, 1905. Serial No. 251,048.



Claim.—In a pneumatic tool, the combination with the casing containing a reciprocating piston and air-chambers at opposite ends thereof, to which the actuating air-pressure is fed through the piston, and from which said pressure is exhausted, of an impact-shoulder in the forward chamber, a bushing seating against said shoulder, a tool inserted at its stem into the casing through said bushing and shoulder, said stem containing a longitudinal groove, a tubular nut screwed through the casing into said bushing, and a spring-pressed stud confined in said nut and working through the casing and bushing to engage said groove, for the purpose set forth.

825,719. HYDRAULIC AIR-COMPRESSOR. Max F. Gutermuth, Darmstadt, Germany. Filed April 29, 1902. Serial No. 105,137.



Claim.—A hydraulic compressor comprises a series of suction-pipes provided with air-inlets, and a compression-pipe having at its upper end a series of tubes or channels each connected with one of the suction-pipes, the said tubes or channels converging downwardly, while the lower portion of the compression-pipe is constituted by a single comparatively wide pipe.

825,786. AIR-BRAKE GOVERNOR. Leonard F. Williams, Thurber, Texas. Filed Aug. 26, 1903. Serial No. 170,849.

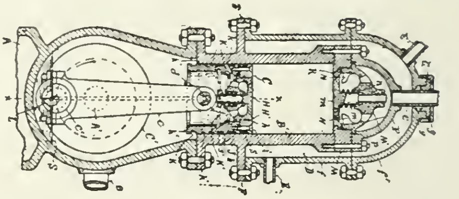
825,935. MACHINE FOR DELIVERING LIQUIDS. Philip Povlotzky, Chicago, Ill. Filed Sept. 6, 1905. Serial No. 277,243.

Claim.—In a machine for delivering liquids, the combination with a valve-controlled supply-pipe, and a delivery-pipe having means to supply air-pressure thereto, of a cup adapted to carry liquid and movable from the supply-pipe to the delivery-pipe.

825,950. STEAM-ENGINE AIR-PUMP. William Weir, Cathcart, Scotland. Filed Sept. 28, 1905. Serial No. 280,492.

825,961. PNEUMATIC HAIR-COLLECTOR. James W. Deckert, Oakville, Canada. Filed Oct. 4, 1905. Serial No. 281,260.

825,973. COMPRESSOR FOR ICE-MACHINES. Casper W. Miles, Cincinnati, Ohio. Filed May 1, 1905. Serial No. 258,198.

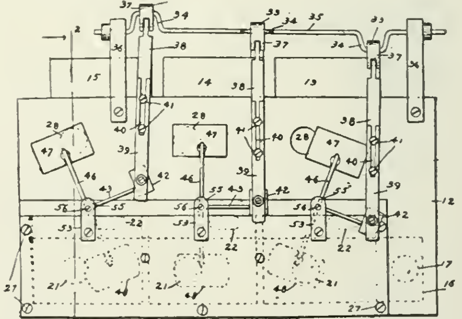


Claim.—In an ice-machine compressor having a jacketed vertical cylinder, and an inlet-valve in the plunger so that the cool gas enters through the plunger and escapes at the upper end of the cylinder, an oil-receptacle on the interior face of the plunger, an annular oil-receptacle at the lower end of the outer face of the plunger, said interior oil-receptacle being at greater elevation than the exterior oil-receptacle, and a passage through the plunger-wall connecting said oil-receptacle.

825,990. FLUID-PRESSURE BRAKE. Walter V. Turner and David M. Lewis, Raton, New Mex., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Aug. 29, 1902. Renewed Nov. 5, 1904. Serial No. 231,542.

Claim.—In a fluid-pressure brake, the combination with a train-pipe and brake-cylinder of a valve for controlling the brake-cylinder-exhaust port, a movable abutment operated by an increase in train-pipe pressure for moving said valve to restrict said port and yielding means for returning said valve to open said port.

825,997. PNEUMATIC MOTOR. Peder Wiggen, Chicago, Ill. Filed Sept. 23, 1905. Serial No. 279,769.

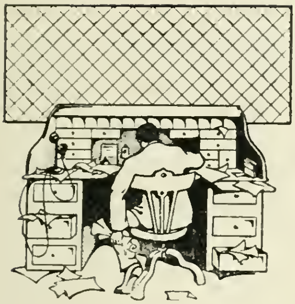


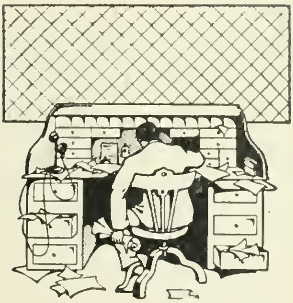
Claim.—In a pneumatic motor, the combination with a main casing or supporting-frame having an exhaust-conduit and provided with inlet and exhaust ports, of a chambered casing inclosing the exhaust-ports, a series of pneumatics on the casing and having communication with the inlet-ports and exhaust-conduit, a crank-shaft journaled on the main frame, connections uniting the pneumatics to the cranks of said shaft, a series of rock-shafts journaled on the frame, an arm mounted on each of said shafts and extending in opposite directions therefrom, a valve on one end of each of said arms to open and close the inlet-ports and a valve on the other end of each of said arms to open and close the exhaust-ports, and connections uniting the rock-shaft and cranks of the crank-shaft, substantially as described.

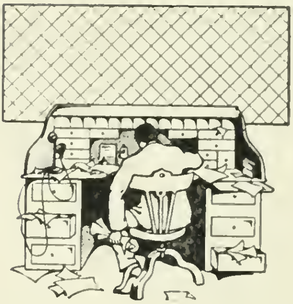
826,018. HOSE-COUPLING. Isaac R. Concoff, Portland, Ore. Filed Nov. 21, 1904. Serial No. 233,770.

826,064. PUMP. John J. Reilly, Louisville, Ky. Filed June 19, 1905. Serial No. 265,902.

Claim.—An air-displacement pump embodying a cylinder, a hollow inclosed supporting-base therefor divided into separate water-inlet and water-delivery compartments which communicate with the cylinder through the top of the base, intake and outlet valves located in the cylinder-bottom and controlling such communication, an air-valve for said cylinder, and valve-operating connections between said valve and a float within the cylinder.







Office

CHIT-CHAT

IT has been said that what is sauce for the goose is sauce for the gander, or, as a later day genius remarked, what is sauce for the goose is saucy for the gosling.

¶ In the interest of COMPRESSED AIR and for the purpose of securing paid subscriptions from a number of people who for one reason or another had been receiving the paper free for various periods, we composed at the expense of considerable grey matter a letter, several hundred copies of which we mailed to our erstwhile "subscribers."

¶ Having sent out this sauce, it is only fair to those who received our hint to reprint some of the sauciness which was handed back to us by return mail.

¶ The letter which we sent out read as follows:

GENTLEMEN:

Sherman said, "War is hell!" We could say the same about building up a good list of subscribers. You have never answered our letter which we sent you when we took hold of "Compressed Air," and we were forced to conclude that you did not think the paper worth anything *unless you got it for nothing*. Much as we should like to scatter our words of wisdom to the four corners of the earth free of charge to everybody, the United States Postal Laws do not permit of our doing this except at an expense which makes our philanthropy look sick.

We have a list of over a thousand people who used to get "Compressed Air" for nothing, and out of that thousand there were ten who responded to our letter and sent us $1.00 apiece when we told them that we could not go on giving our paper away. The other nine hundred and ninety handed us a green lemon, by ignoring our communication and intimating by a vast and deep silence that all the numbers of "Compressed Air" which they HAD received were not worth a paid subscription of $1.00 which we requested in order to *help* put the magazine on its feet.

We are willing to let bygones be bygones but we don't want our old readers to be hasbeens and we are more than willing to meet you three-quarters of the way. Send us your order and we will enter your subscription until JANUARY, 1908, sending you the paper for the remainder of this year. If this does not appeal to you, and if we do not hear from you, we are liable to insist more strongly upon your subscribing even if we have to send each new subscriber a check for $100. Don't put yourself in the position of being under obligations to us, but send us a dollar and get a full dollar's worth of paper, ink and brains in return.

Awaiting your reply with feverish expectancy, we are,

Yours very truly,

¶ At first blush it might seem that a letter such as the above is decidedly too light and airy a method of soliciting subscriptions, but we resolved to take the chance as our former letters, written in a sober and dignified vein, seemed to fall on barren ground.

¶ Imagine the shock on opening the first reply and finding the following:

GENTLEMEN:

Your letter of August 3rd just received. We must confess that it is the worst specimen of an advertising, or business getting letter that we have ever had occasion to read. A more insulting or cheap affair could not be written. If you will take the trouble to glance on your books, you will see that we have a paid up subscription to "Compressed Air" to January 9, 1907. If we subscribe again, it will be because your paper shows extraordinary merits during the remainder of this year, and not because of brilliant, slurring letters like the one just received.

A beginner in an advertising course of instruction would know enough not to use slang in a letter.

Very truly yours,

¶ The second letter which follows caused our editorial hearts to beat faster still.

GENTLEMEN:

I presume that you claim to be gentlemen, and therefore address you as such, but if one may judge from the tone of the communication on the other side there is a big mistake somewhere.

I have received several copies of "Compressed Air" it is true, but I have no recollection of ever having asked you to send it. Of course, if you want to send out copies of your paper you are at liberty to do so, but it is a distinct insult to send such a letter after them. It is also a big business mistake.

You neither gain subscribers nor friends by such methods.

I note that you are awaiting my reply with "feverish expectancy." Well, you have it.

But I think you have another fever coming before the "long expected" dollar arrives.

Yours very respectfully,

¶ When the third letter was opened we experienced a sensation similar to that which one encounters after being thrown into a bathtub full of ice water.

GENTLEMEN:

Some years ago I was asked by the publishers to accept a free subscription to "Compressed Air." I did not want it and declined. The paper came, and twice I requested its discontinuance, but my request was unheeded.

This circular letter is an insult, uncalled for and injudicious. It will make 990 minus rather than possible clients. If I really wanted your publication the receipt of such a concoction of abusive slang would be sufficient to induce me to look elsewhere for any information or instruction in the line of pneumatics.

Yours truly,

¶ There were some more like the above, but our modesty forbids our reprinting them.

¶ The next thirty odd letters opened were as amusing as they were gratifying and lucrative. For fifteen or twenty minutes it rained dollar bills, checks and money orders, but better, far better than the actual currency thrust upon us were the re-assuring sentiments and bantering words which clearly said, "lets be friends." A few of these letters read as follows:

GENTLEMEN:

Yes; "War is hell," likewise are many other affairs in this life, one of which is the parting with your hard earned, sweat covered $$$ without getting v. r. therefor.

To get v. r, is Heavenly, therefore to get ten times v. r. is ten times Heavenly, and here goes One "Simoleon" on the 10 Act, viz.: Compressed Air to January 1st.

Information gained from your last issue worth more than ten times the annual subscription.

With best wishes for your success, I beg to remain,

Yours very truly,

GENTLEMEN:

There is a question in my mind whether the quotation "War is Hell" referred to in your letter is warmer than the letter itself. I do congratulate you upon your able presentation of your situation, and in appreciation of same I enclose herewith my check for $1.00, for which you will please enter my subscription for one year. I am sending this by return mail in order that you will not overwhelm me with a check for $100.

I trust that the "lemon" business is falling off, and that in future it will be confined to "plums."

Yours very truly,

GENTLEMEN:

I beg to acknowledge your very clever follow up letter asking for my subscription. I lived in Missouri and wish to be "shown." I did not mean to hand you a "green lemon" although it was not as green as one which the former proprietor handed me. I received Compressed Air about six years for nothing. Cost value $6.00.

I furnished one article on the pneumatic tube system of St. Louis which would have brought me $15.00 from Eng. News or Eng. Record.

Just before my article was published, I left the pneumatic tube business. My free copy was stopped and I did not know of the publication of my article till a friend told me. I then wrote the magazine and received 3 copies leaving the account thus:

Green Lemon	9.00	
Six yrs. subscription	6.00	
Credit		15.00
By one article		15.00

How about it?

However I am not prejudiced and enclose check for subscription. I am not new in compressed air business and subscribe because I like your methods.

Yours very truly,

By the way I am not dodging any $100 checks.

GENTLEMEN:

Your pathetic or rather urgent appeal Circular of the 3d inst. is received. We find ourselves unable to resist your arguments, and therefore enclose $1.00 which pays for the publication to January 1908.

Trusting that the feverish symptoms will abate on receipt of this, we are,

Very sympathetically yours,

GENTLEMEN;

Enclosed please find check for one dollar which I send you in answer to your letter dated August 3d, 1906, which is, I cannot help remarking, a most remarkable composition. I certainly have never received from you before any request to subscribe, although I have received copies of the paper from time to time, which I understood from a certain source were sent me gratis, and I offered at the time to subscribe in the regular way.

Kindly mail all my communications to my home at 2416 Clarendon Road, Flatbush. Hoping that the enclosed check will obviate any possible repetition of Sherman's verbal explosions, and that you will allow me to express my satisfaction with the general contents of such copies of Compressed Air as I have received from you. I am,

Yours truly,

GENTLEMEN:

I have received your letter of August 3d, and note your distressed condition.

I am going to surprise you by sending you $1.00—this is not so much for the magazine, as for the "Compressed Air" in your letter. I would suggest that if you combine some of the "green lemons" (ripend by this time) which you received, with other ingredients, you might reduce the fever of which you complain.

Yours truly,

¶ It may seem that the above has not much to do with compressed air, but under the heading of Office Chit Chat we enjoy the extreme satisfaction of talking about ourselves and at the same time have an excellent opportunity of extending our apologies to those who may have received one of our War is Hell letters and have as yet been too full for utterance. We qualify our apologies, however, in that they apply only to people who had a legitimate excuse for not having paid their back subscriptions, and we realize that there were many. We apologize to those who acknowledged our letter and sent their subscriptions, the apology in such case, however, being for not sending our letter sooner so as to give them the benefit of subscribing sooner.

¶ To the remainder of our list, those who received our letter, and have not answered it, and have been accepting and reading COMPRESSED AIR without the formality of paying, we extend our greetings and assure them that while their silence may be irritating we cannot but admire their rhinocerous-like indifference to appeals, the preparation of which is so labored and the mailing of which is so painful and yet so necessary.

THIS is the only publication devoted to the useful applications of compressed air, and it is the recognized authority on all matters pertaining to this subject.

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THIS is a weekly journal, edited by HALBERT P. GILLETTE, author of Handbook of Cost Data, Earthwork and Its Cost, Rock Excavation, etc. The articles in ENGINEERING-CONTRACTING form a sequel to Mr. Gillette's books, being, for the most part, articles on the methods and costs of doing work. In addition to these articles, the contract news of the week is given. This news service is believed to be superior in point of promptness and accuracy to the news in any other engineering or contracting paper. Mr. C. T. Murray, who has been in charge of the contract news department of Engineering News until last December, is now in charge of our contract news department. Mr. Gillette, who has written for other papers in the past, including Engineering News, will write only for the ENGINEERING-CONTRACTING hereafter. His series of articles on Cost Keeping on Contract Work, now running, should be read by every contractor and engineer.

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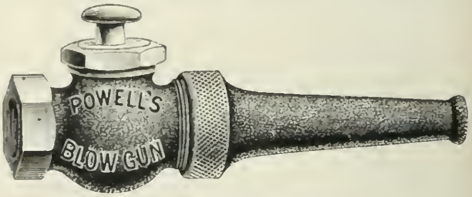

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THE WM. POWELL CO., Cincinnati, Ohio,

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

OCTOBER, 1906.

VACUUM PECULIARITIES.

Written for Compressed Air by Edward F. Schaefer, M. M. E.

To the Editor of Compressed Air:

Dear Sir:—There are various points in the paper "Vacuum Peculiarities" which have occasioned more or less comment, and so as to modify the opinions already expressed and to secure further information on the subject, I would suggest that the paper be opened to your readers for discussion.

Edward F. Schaefer.

Vacuum is space devoid of matter.

In practice a perfect vacuum cannot be obtained. Even with the excellent compressors and suction pumps in operation to-day, an approximation only to the ideal vacuum is possible.

Moreover, a perfect vacuum is not necessary in dealing with the infinite problems in engineering that are up for discussion each day. Of course, the perfect is always desirable, but the partial is sufficient.

The engineer understands vacuum to mean a condition of matter where the attending pressure is below atmosphere, and the usual forms of matter with which he has to deal, in connection with vacuum, are gases such as steam and air. The pressure of the atmosphere at sea-level is 14.75 pounds per square inch; it is evident then that the range of pressures under which vacuums exist is between zero pounds per square inch absolute and 14.75 pounds per square inch absolute.

The degree of vacuum is commonly expressed by inches of mercury; thus, when air in a vessel is subjected to an absolute pressure of 6 pounds per square inch absolute, it is said that the gas has a vacuum of 17.7 inches of mercury (17.7" Hg). At 14.75 pounds or at atmospheric pressure, the vacuum is zero inches, and at zero pounds the vacuum is 29.9 inches of mercury.

Curious as it may seem, it takes more power to maintain a vacuum of 9 pounds absolute than it does to maintain one of, say, 0.5 pounds per square inch absolute. Obviously it takes no power whatever to move a piston back and forth in a perfect vacuum, and further it takes no power to move a piston in *no* vacuum or at atmospheric pressure (neglecting friction). Between these extreme points it takes more or less energy, depending upon the pressures.

The expression which follows must at first sight appear absurd.

"It takes more power to maintain a vacuum of 7 pounds absolute than to maintain one of 1½ pounds, since it takes no power (except friction) to move a piston back and forth in a perfect vacuum; it also takes no power to move a piston in *no* vacuum since there will be atmospheric pressure on both sides of the piston."

To the author this statement appeared so peculiar that he made a detailed investigation of it and worked out the horsepowers for both single and two-stage compression, between the limits of zero pounds per square inch absolute and 14.75 pounds, taking increments of one pound. The fact found was that the maximum horsepower for single stage compression is for compressing between 4 and 5 pounds to 14.75 pounds, and for two stage compression the maximum was found to lie between 5 and 6 pounds pressure.

To determine exactly where these points fell, the Calculus was employed, and it was discovered that the maximum horsepower for simple compression is required when the vacuum pressure is 4.521 pounds per square inch. In the case of two-stage compression the maximum horsepower is necessary when the initial pressure is 5.004 pounds.

The quotation above was therefore found to be correct in expression, although incorrect in numerical values.

Horsepower whether single or two-stage is expressed by

$$\text{H. P.} = 0.00436 \text{ M. E. P.} \ldots\ldots (1)^*$$

In this expression M. E. P. signifies mean effective pressure.

For single stage compression

$$\text{M. E. P.} = 3.45\, P_v \left[\left(\frac{P_a}{P_v} \right)^{0.29} - 1 \right] \ldots\ldots (2)^*$$

For two-stage compression

$$\text{M. E. P.} = 6.90\, P_v \left[\left(\frac{P_a}{P_v} \right)^{0.145} - 1 \right] \ldots\ldots (3)^*$$

In these equations both P_v and P_a must be expressed in pounds per square inch.

P_a = 14.75 pounds per square inch; this is atmospheric pressure at sea level and is a constant.

P_v = pressure of the vacuum desired.

These formulae were employed in securing the table showing the M. E. Ps and H. Ps for both single and two stage compression.

To determine the exact location of the max-

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*See "Derivation of Formulae for Simple and Stage Compression" by E. F. Schaefer. *Compressed Air, Vol. XI. No. 1.*

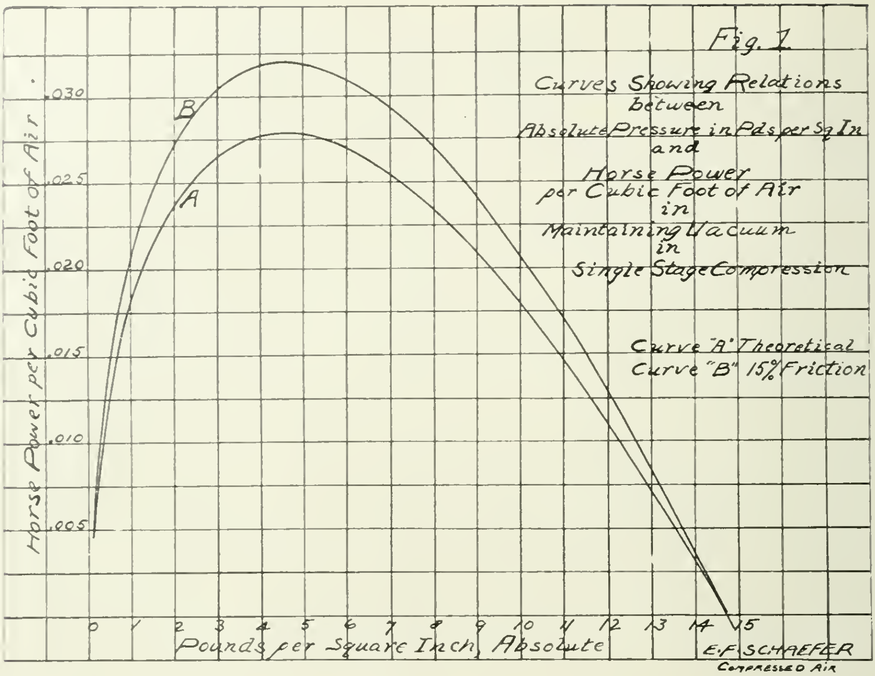
Fig. 1
Curves Showing Relations between Absolute Pressure in Pds per Sq In and Horse Power per Cubic Foot of Air in Maintaining Vacuum in Single Stage Compression
Curve "A" Theoretical
Curve "B" 15% Friction
B
A
.030
.025
.020
.015
.010
.005
Horse Power per Cubic Foot of Air
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Pounds per Square Inch, Absolute
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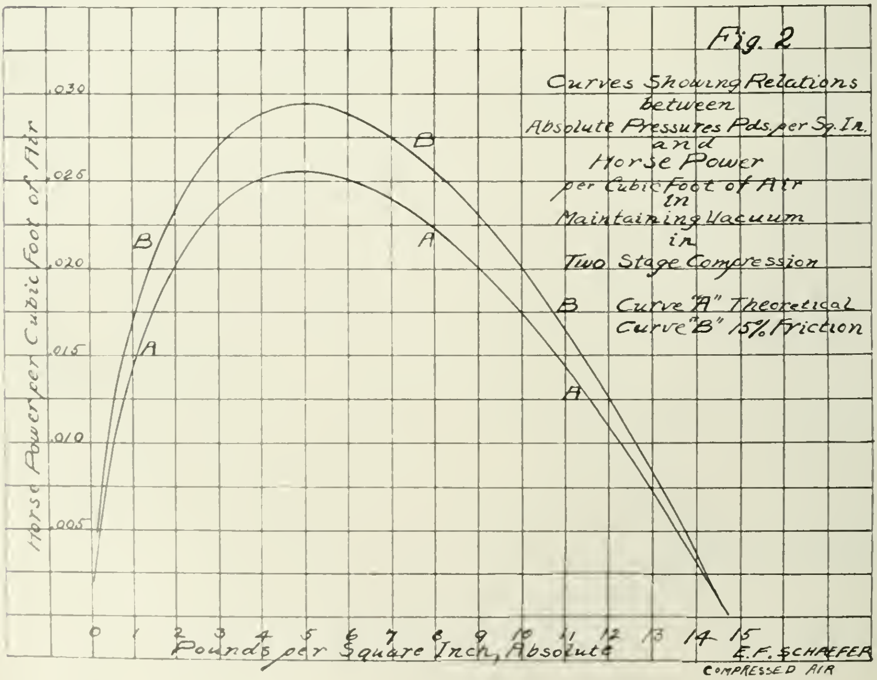


Fig. 2
Curves Showing Relations between Absolute Pressures Pds. per Sq. In. and Horse Power per Cubic Foot of Air in Maintaining Vacuum in Two Stage Compression
Curve "A" Theoretical
Curve "B" 15% Friction
B
A
B
A
B
A
.030
.025
.020
.015
.010
.005
Horse Power per Cubic Foot of Air
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Pounds per Square Inch, Absolute
E.F. SCHAEFER
COMPRESSED AIR

imum points, equations (2) and (3) were differentiated. The first differential coefficients of the M. E. Ps as functions of the vacuum pressures were then made equal to zero and the equations solved for P_v. In the case of single stage compression $P_v = 4.521$, and for two stage $P_v = 5.004$.

The expressions were then differentiated a second time to secure the second differential coefficients of the M. E. Ps as functions of P_v In each case the result was a negative quantity, proving 4.521 and 5.004 to be maximum values.

For simple compression we have in detail

$$\text{M. E. P.} = 3.45\ P_v \left[\left(\frac{P_a}{P_v}\right)^{0.29} - 1\right]$$

$$= 3.45\ P_v \frac{(P_a)^{0.29}}{(P_v)^{0.29}} - 3.45\ P_v$$

$$= 3.45 \left(P_v\right)^{1-0.29} \left(P_a\right)^{0.29} - 3.45\ P.$$

$$= 3.45 \left(P_v\right)^{0.71} \left(P_a\right)^{0.29} - 3.45\ P_v$$

Differentiate

$$d\,(\text{M. E. P.}) = 3.45 \left(P_a\right)^{0.29} d\left(P_v\right)^{0.71} - 3.45\,dP_v$$

$$\frac{d\,(\text{M. E. P.})}{d\,P_v} = 3.45 \left(P_a\right)^{0.29} \times 0.71 \left(P_v\right)^{0.71-1} - 3.45 = 0 \quad (4)$$

$$\therefore \left(P_a\right)^{0.29} \times 0.71 \left(P_v\right)^{0.71-1} = 1$$

$$\left(P_v\right)^{-0.29} = \frac{1}{0.71\ P_a^{\ 0.29}} = \frac{1}{1.549}$$

$$\left(P_v\right)^{0.29} = 1.549$$

$$\left(P_v\right) = \left(1.549\right)^{\frac{1}{0.29}}$$

$$P = 4.521 \quad \ldots\ldots\ldots\ldots\ (5)$$

Differentiate (4) a second time.

$$\frac{d^2\,(\text{M. E. P.})}{d\,P_v^{\ 2}} = 3.45 \left(P_a\right)^{0.29} \times 0.71\,(0.71-1 \left(P_v\right)^{0.71-2}$$

$$= -2.$$

which is an even order and negative showing that $P_v = 4.521$ corresponds to a maximum.

The same solution was applied to equation (3) for two stage compression and it was

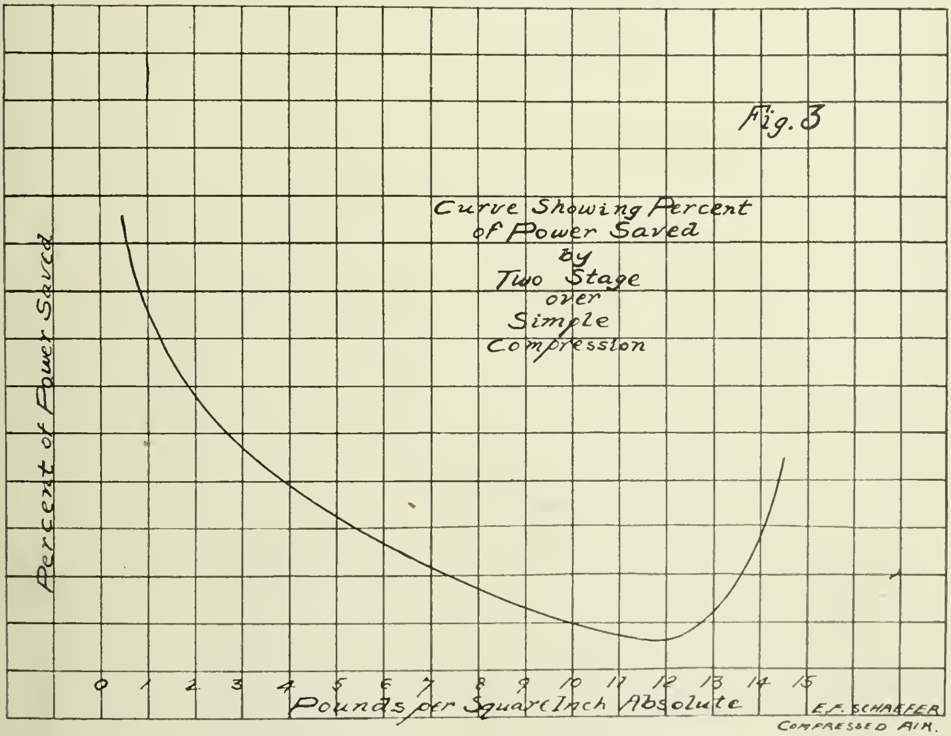


Fig. 3

Curve Showing Percent of Power Saved by Two Stage over Simple Compression found that when $P_v = 5.004$ the value was a maximum.

For the vacuum pressure 4.521 pounds the M. E. P. for single stage compression is 6.379 pounds per square inch, giving as the theoretical developed horse-power per cubic foot of air 0.02781. For this same pressure the horse-power for two stage compression is 0.02543. The percentage of power then saved by two stage over simple compression, for this case, is expressed by (0.02781 — 0.02543) ÷ 0.02781 or 8.6%.

It will be seen that in the tabulated list an additional item is found for both single and two stage compression. It reads "Developed horse power 15% friction included." The figures under this head are what are used in actual calculations, since in them are included the various frictions due to the piston, cross-head, crank-pin, etc.

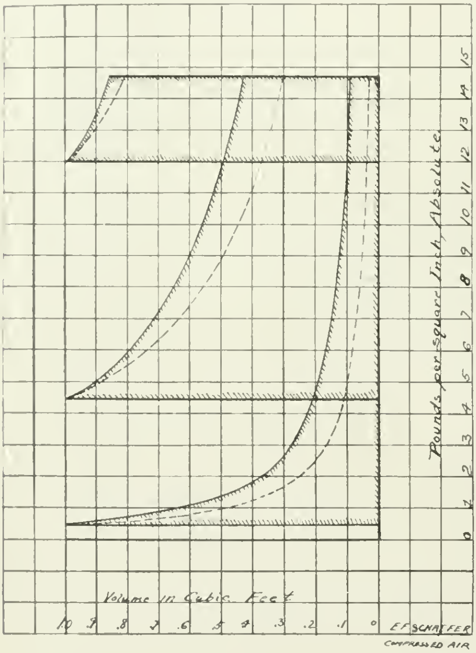


Fig. 4.

The compressor cylinders when employed for purposes of producing vacuum are seldom water-jacketed. A jacket is hardly necessary since the air which is compressed, although it has the same temperature range as when compressed under corresponding ranges above the atmosphere, has less *capacity* for heat due to its rarified condition.

This lack of heat capacity of air under pressure below normal obviates the use, in most instances, of intercoolers for two stage compression. The results in the table were secured by assuming that an intercooler was employed and that the air entered the high pressure cylinders at 60° Fahrenheit. Using the intercooler when operating under a vacuum of 28.94 inches of mercury will effect a saving of 23.9% in power.

Of course in cases where the intercooler is dispensed with the horse-powers for single and for two stage compression are identical. The advantage of compounding without using the intercooler is to reduce the losses due to clearance.

HORSE-POWER DEVELOPED

in adiabatically compressing and in discharging one cubic foot of air from various degrees of vacuum into the atmosphere (14.75 # □″).

Initial temperature of air in each cylinder taken as 60° Fahrenheit.

Jacket cooling not considered.

E. F. Schaefer.

Vacuum.		One-Stage Compression.			Two-Stage Compression.			
Absolute pressure. Pds. per sq. in.	Inches Mercury.	M. E. P. per sq. in. (Theoretical)	Developed H. P. (Theoretical)	Developed H. P. 15% friction included.	M. E. P. per sq. in. (Theoretical)	Developed H. P. (Theoretical)	Developed H. P. 15% friction included.	Per cent. of power saved by two-stage over one-stage comp. (Theoret'c'l)
0	29.90	0.000	.00000	.00000	0.000	.00000	.00000	——
0.5	28.94	2.877	.01254	.01442	2.187	.00954	01097	23.9
1	27.88	4.081	.01779	.02046	3.291	.01435	.01651	19.3
2	25.85	5.417	.02362	.02716	4.637	.02022	.02325	14 4
3	23.81	6.075	.02649	03046	5.361	.02337	.02688	11.7
4	21.77	6.348	.02768	.03183	5.741	02503	.02878	9.6
4.521	20.80	6.379	.02781	.03198	5.833	.02543	.02924	8.6
5	19 74	6.348	.02768	.03183	5.865	.02557	.02941	7.6
5.004	19.70	6 353	.02770	.03186	5.870	.02559	.02943	7.6
6	17.70	6.169	02690	.03094	5.755	.02509	.02885	6.7
7	15.66	5.820	.02538	.02919	5.506	.02401	.02761	5.4
8	13.63	5.354	.02334	02684	5.134	.02238	.02574	4.1
9	11.59	4.782	.02085	.02398	4.595	.02003	.02304	3.7
10	9.55	4.106	.01790	.02059	4.002	.01745	02007	2.5
11	7.51	3.378	.01473	.01694	3.317	.01446	.01663	1.8
12	5.48	2.525	.01101	.01266	2.484	.01083	.01246	1.6
13	3.44	1.659	.00723	.00832	1.614	.00704	.00810	2.7
14	1.40	0.725	.00316	.00363	0.676	.00295	.00339	6.7
14.75	0.00	0.000	.00000	.00000	0.000	.00000	00000	——

Fig. 1 shows the relations between various degrees of vacuum and the horse-powers necessary to maintain the same when compressing in a *single stage*. Two curves are shown, one giving the theoretical, and the other the actual relations when friction is included.

Fig. 2 is identical with Fig. 1, except that it is constructed for *two stage* compression when an intercooler is employed. In both Figs.

1 and 2 the points at which the maximum values fall are clearly defined.

Fig. 3 gives the variations in per cent. of power saved by two stage over simple compression for various vacuums. It will be noted that minimum saving in power is effected when maintaining a vacuum of 12 pounds or 5.48 inches mercury. (The calculus is necessary for determining the exact point but 12 pounds is sufficiently close for all purposes.)

VOLUMES IN CUBIC FEET

when compressing one cubic foot of air from various degrees of vacuum to various absolute pressures. E. F. SCHAEFER.

ABSOLUTE PRESSURES. Pounds per square inch.		VOLUMES. Cubic Feet.	
P_1	P_2	Isothermal. $(P_1 \div P_2)$	Adiabatic. $(P_1 \div P_2)^{0.71}$
0.5	14.75	.0339	.0905
0.5	10.00	.0500	.1192
0.5	8.00	.0625	.1397
0.5	6.00	.0832	.1711
0.5	4.00	.1250	.2285
0.5	2.00	.2500	.3737
4.521	14.75	.307	.4324
4.521	12.00	.377	.5003
4 521	10 00	.452	.5691
4.521	8.00	.565	.6667
4.521	6.00	.753	.8160
4.521	5.00	.904	.9310
12.000	14.75	.813	.8633
12.000	14.00	.857	.8962
12.000	13.00	.923	.9447
12.000	12.50	.960	.9715

Fig. 4 consists of three indicator cards gotten when compressing adiabatically from 0.5, 4.521 and 12 pounds absolute to atmospheric pressure. The isothermal compression curves are also indicated by dotted lines. These cards show more clearly, perhaps, than our horse-power curves just *why* it takes less power to compress from pressures either side of 4.521 pounds. A planimeter might advantageously be brought into play and it will be found that the areas are in the same ratios as the M. E. Ps.

In plotting these cards the fundamental formula for adiabatic compression was employed.

$$P_1 V_1^n = P_2 V_2^n$$

V_1 = unity therefore V_1^n = unity

$n = 1.41$

therfore $V_2 = \dfrac{P_1}{P_2}$

or $V_2 = \left(\dfrac{P_1}{P_2}\right)^{\frac{1}{n}} = \left(\dfrac{P_1}{P_2}\right)^{0.71}$

For isothermal compression

$$V_2 = \frac{P_1}{P_2}$$

A saving in power is a saving in coal and this is a saving in money. In operating vacuum pumps it must be evident from what has been said that it is highly advantageous *not* to maintain a pressure near 4.521 pounds per square inch absolute. By keeping away from this maximum energy point, economy is effected.

A NEW ASHPIT.

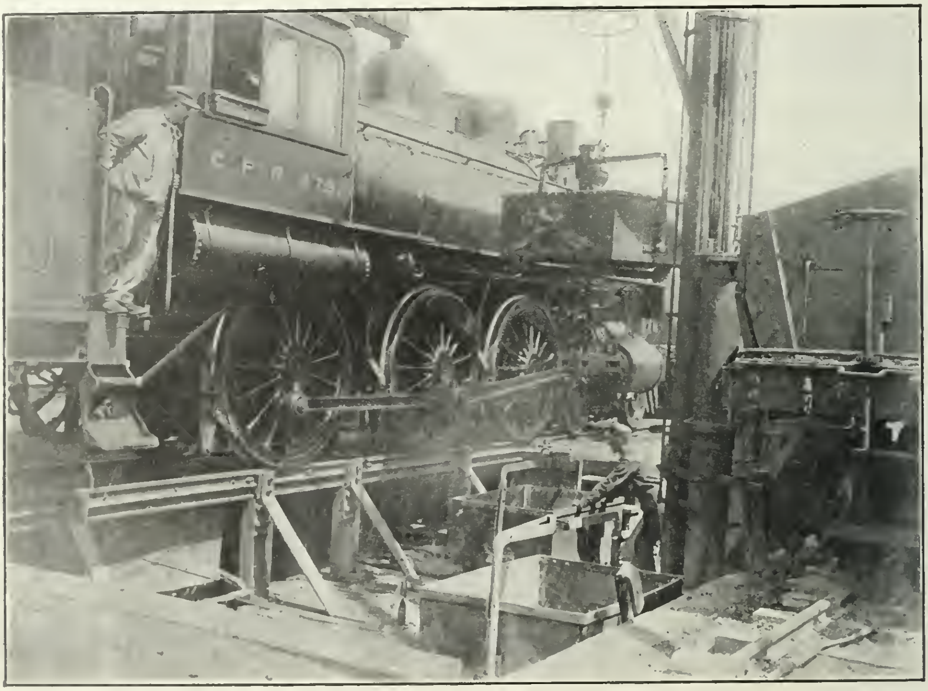
Written for COMPRESSED AIR.

One of the most important features in connection with the despatching of locomotives at roundhouses is the Ashpit over which the fire is cleaned, and into which the ashes are dumped. Also the means for removing the ashes from the pit, and loading them on to cars.

The first form of ashpit for this purpose was constructed with its sides immediately under the rails of the track, upon which the locomotive would come on to the turntable, and thence to the roundhouse. The track is usually called the "incoming" track.

These pits were of different lengths, according to the number of engines arriving per day. They would be of sufficient depth so that a man could stand in them and conveniently work a hoe or scraper at either end of the ashpan and draw the ashes out, allowing them to fall into the pit. The locomotive would then be moved off the pit into the roundhouse, and the ashes would be shovelled out of the pit on to the surface of the ground, and while this was being done another engine could not come over that portion of pit, but, if the pit was long enough, it could have its fire cleaned at another point on same. If, however, it was not long enough for this, it would have to wait until the ashes in the pit were thrown out, or else have its ashes dumped in the same place, which would soon result in the pit becoming full of ashes, so that it would be absolutely necessary for the engines to be kept off the pit until the ashes were thrown out. It was therefore better, after each engine had had its fire cleaned, to throw out the ashes, no matter whether the pit was long or short. This was not only expensive in the handling of ashes, but often caused delay to power.

The ashes now at the side of the pit had to be thrown on to the cars, and if the pit was long there would require to be a sufficient number of ash cars to correspond to the length of the pit, so that the ashes thrown out of the pit at any point could be thrown on to a car. In some cases buckets have been placed in the pit to receive the ashes direct from the pan, and when the engine was moved off the pit, the buckets would be hoisted and dumped on to the ash car and the bucket returned again to the pit, but until the buckets were replaced, another engine could not come on to the pit. This therefore was objectionable on account of delay to the engines.



VIEW NO. I.

If the switching out of cars, when loaded, and placing of empty cars was not regularly attended to, a pile of ashes would collect at the side of the pit, and in winter time would freeze, on account of having been wetted as they were drawn out of the pan, to prevent the dust from getting on the engine. The removal of the frozen pile would cost still more, and in summer, if hostlers were not very careful, the steam from the cylinder cocks would blow the ashes over the engine.

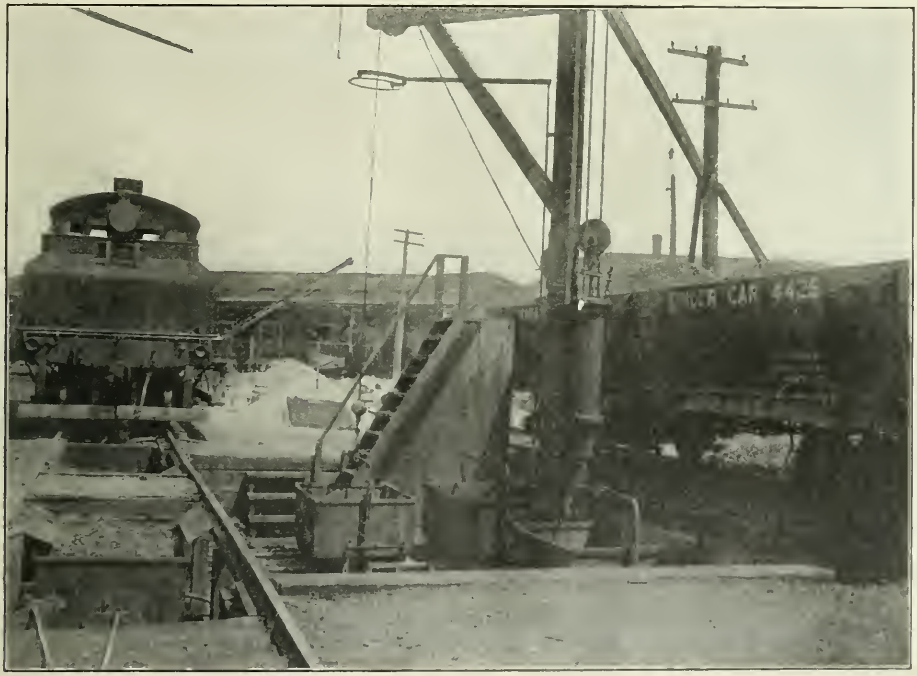
The only satisfactory way therefore of doing this work was not to allow the ashes to accumulate in the pit or at the side of the pit.

To overcome the difficulties above outlined different improvements have been introduced.

Other arrangements have been introduced where a bucket on wheels would run down rails on an inclined plane, entering the pit from the side by going underneath the rail. This form would not keep the engine waiting, while the bucket was being drawn out when full, but it worked from one end of the ashpan only, and a second apparatus of the same type would be needed to dispose of the ashes at the other end of the ashpan.

It further would dump the ashes on the car at the same point as each following bucketful was drawn up and the car would need constant shifting. The arrangement was further objectionable as the rails upon which the bucket ran upward extended over the ashcar track, preventing a high car or an engine coming on this track.

There is another form of ashpit, known as the "Open Side Ashpit," with depressed ashcar track. This pit has the rail on one side, supported on columns or standards, and the ashes can be shovelled out from the side; the man doing the work of shovelling stands at the side of the pit on the same level as bottom of pit, and in order that he will not have too high a throw for the ashes, the ashcar track is depressed, the rails being about on a level with the bottom of the ashpit. With one shovelling, therefore, the ashes are thrown from the bottom of the ashpit onto the car.



VIEW NO. 2.

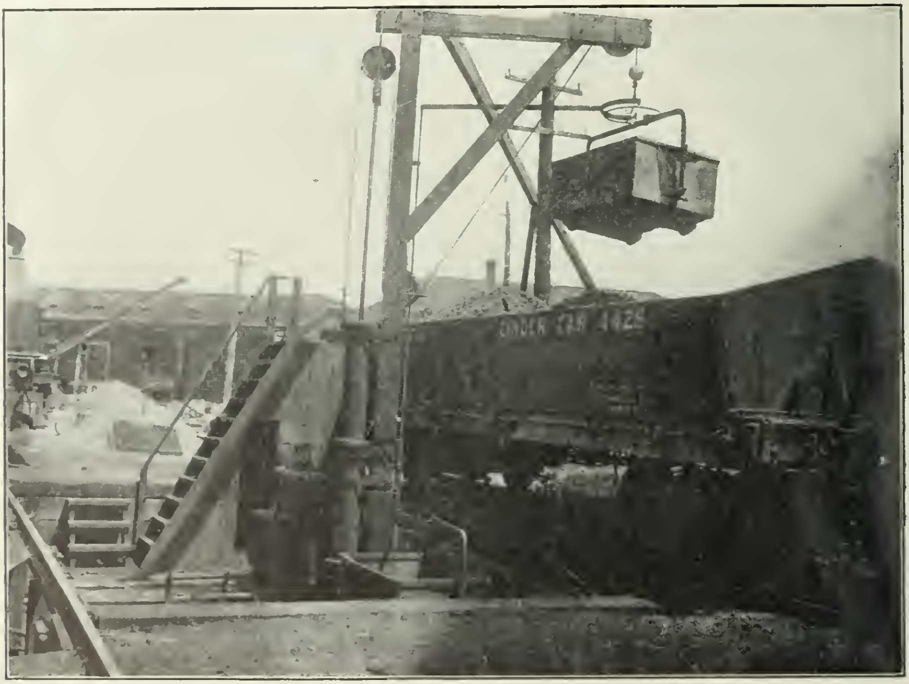
With this kind of pit there need be no delay to engines, but it is expensive, as in the first place the ashes are all loaded by hand, and where many engines are coming in, the pit must be long, and there would require to be sufficient cars to cover its full length, also a laborer cannot throw ashes over a high-sided car and heap them up, consequently more cars are needed. Watering facilities are also needed to cover the length of a long pit of this description, so the ashes can be wetted at whatever point the engine may be stopped. These arrangements if not properly protected will freeze, and a free use of water washes the ashes into the drain, floods the depressed track and covers it with ice.

It must also be remembered that where the first engine comes on a long pit, it is placed at the end nearest the turntable; other engines follow and take positions on the pit, and the work of fire cleaning is begun as each engine is placed. When the first and second have had the fire cleaned the third may only have its fire half done. This prevents that portion of the pit which was occupied by the first and second engine being used until the third has had its fire cleaned and is moved off the pit.

The accompanying photographs give different views of an ashpit which was designed and patented by C. R. Ord, Master Mechanic of the Atlantic Division of the Canadian Pacific Railway, and it is claimed by the inventor that all the objections above mentioned have been overcome in this device.

View No. 1. Loaded bucket can be seen partially hoisted over further track in pit, and man in pit pushing spare empty bucket into position under ashpan, formerly occupied by bucket now being hoisted with load of ashes to be dumped into car.

View No. 2. View of ashpit with locomotive standing beyond. One loaded bucket has been drawn from under the rails and is about to be hoisted by crane, cable being coupled to same. The other loaded bucket can be seen between the rails, with aprons which are secured to each rail, preventing the ashes from falling outside of buckets as they are raked out of ashpan. The spare empty bucket is now standing at the outer part of pit. The guides for directing the buckets onto the rails after they have been emptied can also be seen in this view.



View No. 3. A view of ashpit with one bucket hoisted and swung directly over ashcar, man standing at crane with right hand on lever, by which the crane is swung, and left hand on lever of dumping apparatus by which the latch of bucket is thrown out and bucket allowed to turn over and dump ashes.

View No. 4. View of ashpit with crane, showing the steel cable of crane connected to a heavy manilla rope, later passing around pulley which is secured to further side of ashpit, the other end of rope to which a hook has been spliced, connected to ashcar, the car being drawn into position by means of crane, doing away with the necessity of switch engine to shift cars in order that they may be fully loaded. This crane moves six cars in this manner.

From these views it can be seen that the locomotives can be moved on and off the pit without in any way interfering with the removal of ashes as the loaded buckets are drawn out under the rail, and while the loaded bucket is being hoisted, if need be, the empty one can immeiately be pushed under to receive any remaining ashes, or to be ready for another engine. There are four buckets in the pit, two for each end of ashpan. They hold 1,500 pounds of ashes, and have smokebox setting in the bottom to let the water run out, but prevent large cinders from blocking the drain.

The tracks upon which the buckets move are made of common iron piping, and steam passes through them in cold weather, keeping the oil from freezing on wheels of buckets, and also keeping the pit free of snow and ice in the winter time.

At each end of the pit extra openings can be seen under the rails for the men to get under the engine and rake the ashes from each end of the ashpit and avoid the danger of crawling between the wheels. When the men are in position at each end of the pan the buckets stand immediately in front of them, and the ash hoes are kept at each end of the pit, between rails, and can be drawn forward when needed. There is also a very convenient arrangement for each man for wetting the ashes. A pair of pipes come through the side of the pit at each end, one for steam and the other for water. Valves are placed just clear of pit wall, and beyond the valves the two pipes are joined in one, to which a length of hose is attached. When not in use in cold weather the water valve is shut and a slight escape of steam keeps the hose from freezing. Water can be used for wetting the ashes, or steam for thawing frozen ashpans.

With the crane for hoisting the buckets a very heavy load of ashes can be put on the car to any desired height. The dumpings can be distributed over the car and one shift only is needed to fill it from end to end. The next car can be then drawn into position by crane, as shown in view No. 4.

Two of these pits have been in operation, one at McAdam, N. B., and the other at Brownville, Me., for over two years, and have given perfect satisfaction during two of the hardest winters experienced for many years. The cost of labor of loading ashes on the cars has been one cent per ton. Average time taken to draw buckets from under engine, dump ashes on car and replace under engine is three minutes. In ordinary business one man on each shift has hoisted the ashes, hoed out one end of ashpan, placed the ashcars and dried the sand.

VIEW NO. 4.

With the crews handling incoming engines about fifty engines can be handled per day on this pit. An engine is put on the pit, fire cleaned and put in the house. The following engine is put on the pit by second crew. The first crew returning from engine-house take charge of third engine, which they coal, sand and water, and by this time the second engine has the fire cleaned and is ready to move on turntable.

The pit is 36 feet long between the rails to give room to work the hoe. Outside of rails it measures 27 feet, and is therefore bridged by one rail. The width from rail to ashcar track is 15 feet.

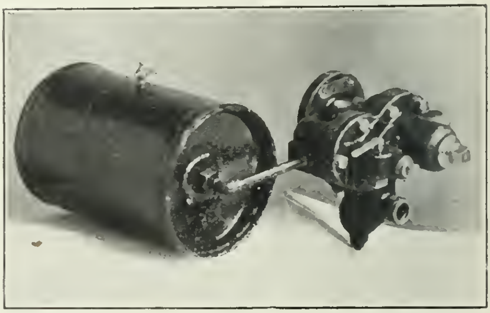
The ash buckets are 5 feet long, and are so situated as to suit engines with long or short ashpans. They are operated by compressed air.

AN IMPROVED TRIPLE VALVE.

Written for COMPRESSED AIR.

A new triple valve has just been invented by Oliver L. Goodnight, member of the Air Brake Association, to overcome the disadvantages of the present system of air brake control. After large locomotives were introduced upon modern railways, for hauling long trains, it became apparent to trainmen that the air brake was not yet perfect, as, in the case of a long train running at a slow rate of speed and making release without stopping, release would begin at the head car and continue serially, thus ending upon the rear car and causing the slack to run ahead from the rear end with such sudden force that in many cases danger resulted to the train rigging, and draw boards, and delays to traffic were frequent on account of the breaking apart of the train. The new valve is designed to overcome these difficulties.

The illustration shows the exterion appearance of this apparatus with controlling valve placed at a right angle. Constant pressure, equal to the normal brake pipe pressure, is maintained in the drum, and also against the release piston on opposite side of brake pipe. This permits the engineer to apply brakes and re-charge to normal brake pipe pressure by moving the brake valve handle from lap to running position, thereby forcing the guiding piston to assume position of release. With the head brakes in this position, which is high pressure release, and the small valve handle placed as shown in the illustration, in a straight line position on the rear brakes, which is low pressure release position, the rear half of the train, or any portion that may be determined, will be released in advance of the head brakes, while at the same time the entire train may be re-charged, and the slack allowed to bunch forward in readiness for releasing head brakes, by moving the brake valve handle to full release position; or, should it be desired to make a quicker and more sure release following the usual application, the brake valve handle may be moved from lap to full release position, then immediately back to lap position; the main receiver pressure will then back through the brake pipe, forcing all triple valves to assume a release position; and, on account of brake valve handle being placed again at lap position, the pressure will immediately drop below normal in the brake pipe; this is due to feeding through the feeding grooves into the auxiliary receivers and allowing the pressure in the small drum to force the release position immediately back on lap position and close the inside ports of the triple valves. Thus a portion of the brake cylinder pressure will be held and the brakes remain applied with reduced brake cylinder pressure. At the same time the rear brakes will be fully released.



EXTERIOR VIEW OF NEW TRIPLE VALVE.

Retaining valves on cars are disposed with entirely and the engineer is given full control of the brakes upon a train at all times, without depending upon trainmen to operate the retaining valves. It is claimed that this brake can be applied and released from the engine just as easily as any other brake with triple valves regulated in either position. Furthermore, the apparatus has all the advantages of being standard and interchangeable with present air brake systems. The important features may also be attached to the present triple valve on a car without necessitating any changes. The device is patented in the United States and foreign countries with further patents pending.

THE EDUCATION OF MINING EGINEERS.

BY J. W. GREGORY.*

The fundamental difficulty in mining education is the fact that the mining engineer requires a training which must be both unusually wide and thorough. The miner's knowledge must be exceptionally varied, for he often has to work in remote localities, where he must be self-reliant; at the same time his work requires a high standard of attainment. He needs to be well versed in many branches of civil, mechanical, and electrical engineering, and, at the same time, his knowledge of chemistry, geology, and mineralogy must be sufficiently sound to be practically useful. The mining engineer, in fact, must have the most of the training of an ordinary engineer, for he may be called on to lay down railways, build bridges, erect large workshops and furnaces, construct dredges and dig vast excavations. And in addition to these qualifications he must have his special mining education as well. This burden is, however, not unfairly heavy, for the rewards of the successful mining engineer are great.

The first serious fault in the existing schemes of British mining education seems their failure to recognize this essential requirement, as shown by the inadequate length of the courses. The American and Australian universities insist upon a course of four or five years.

The answers to the inquiries of the committee of the Institute of Civil Enigneers (London) show that in Great Britain the length of course favored for a civil engineer is three years at a university or technical college and four years in practical training in workshops. If this seven years' course be necessary for a civil or mechanical engineer, it seems impossible to train a competent mining engineer in two years of theoretical and one year of practical work. The mining engineer should have the three years' theoretical training, like the civil engineer, and at least one year extra for his special work. And granting a college course of that length, then two or three years of practical work would, in the majority of cases, probably be adequate. One year's work in the machine shop of a large colliery would be the best preliminary practical course available for British students, and then three or four long vacations, each of not less than four or five months, spent in mines, should supply the necessary amount and variety of practical training.

The proportion of time spent in practical training may be less in mining than in mechanical engineering, but the use made of a spell of practical work should be more closely watched, to avoid the deplorable waste of time that often occurs in it. Many a student puts in a period of "practical work" which consists only of such jobs as trucking. Time thus spent is wasted to a mining engineer as it would be to a lawyer if his first year in articles were spent in cleaning office windows or polishing the brass-plate on the front door.

It is said that there is no chance in this country (Great Britain) of students of mining engineering undertaking so long a course of study as is required for medical qualifications. If it be the case that the British mining course is to be limited to two or three years, then it seems to me hopeless to expect British mining education to reach really front rank. The American institutions have often great wealth, which is, moreover, less mortgaged to subjects of secondary value; and their constitutions are more elastic. There seems little chance of our less free educational institutions reaching, in a two years' course, the level for which more advantageously placed American universities are willing to give five years.

The educational committee of the Institution of Civil Engineers complains that "at present a considerable proportion of students enter technical institutions ill-prepared, and at least one year has to be devoted to instruction which ought to be secured beforehand."

The main drawback of the long academic year is that it is fatal to the "sandwich system," by which students can spend six or seven months at a university and the other five or six months in practical work. There are obvious objections to this course. The most serious is that the expensive teaching equipment has long intervals of idleness, except in so far as it may be used for research work and by honors' students during special summer courses. In technical subjects, however, the advantages of the "sandwich system" seem to me far to outweigh the drawbacks. Employers complain that the students of some of our best universities and colleges come from them with an academic spirit, which spoils the men for years and sometimes hampers them for life. The writer remembers being surprised, on trying to persuade a chemical manufacturer to give an appointment to a student from what he considered probably our most efficient technical college, to hear the men previously engaged from it had proved useless owing to their impracticability. The knowledge of the men was admittedly sound, but it was said that they could not apply it, owing to lack of common sense and practical insight. The spirit of a university and a college is remarkably different from that of the business world, and success in the complex profession of mining requires commercial instincts as well as technical knowledge. It seems to the writer most important that students who intend to adopt a technical profession should not be kept for some years continuously in a college atmosphere. The contact for six months in the year with the practical work of the world gives the necessary corrective, and is invaluable educational training.

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* Abstract of paper read recently before the Istitution of Mining Engineers, London.

Manufacturers and mine managers do not care to engage students who cannot stay more than from four to six months. The "sandwich system" is most practicable for schools which are situated on or near mining fields, or in which the staff are personally well acquainted, perhaps by consulting practice, with mining authorities. Schools, on the other hand, which are separated from mining, geographically or personally, will generally tend to prefer that the course of study should run continuously, and that the practical training should be gained either before or after the college course.

The "sandwich system" is economical of the students' time, for it enables them, by the change from college study to manual exercise, to work throughout the year without risk of injury to health, or of becoming stale. Accordingly, in three years a student can put in 34½ or 35 months' work, whereas with a college session of nine months, the vacations are too short to be of practical use, and the three years give only 27 working months.

The "sandwich system," moreover, renders it much easier to equip schools economically, for if the students see the current methods in actual use, and mining operations and metallurgical equipment on a large scale, there is less need for burdening our laboratories with full-sized mining plants.

The drawbacks of a full-sized equipment are that it is soon out of date, and then is most expensive to renew; while it is such a glutton for material that its running is a heavy drain on the revenue of a department. Some schools recoup the expense of using such machinery by treating ore commercially. But in such cases the tendency is for the plant to be handled by trained mechanics, and the students are not allowed to take much share in the actual work, for the mistakes, which are all important educationally to the student, cannot be allowed to occur. Such commercial practice in a college seems to me usually unsatisfactory, with some obvious exceptions.

There is a general agreement as to the main outline of the course of instruction required by the mining engineer, and the differences in detail are largely due to the varying local opportunities and requirements. Coal miners need most mechanical engineering, including ventilation, and metal miners most geology, while copper miners, in addition to geology, need ample metallurgy.

The amount of geological teaching in this country in mining seems to me very inadequate, and America has led the way in a fuller recognition of the needs of geology in mining. The Royal School of Mines adopts the excellent method of taking one subject at a time, working at it all day and every day till the amount of time devoted to the subject is exhausted. This system of continuous running has many recommendations, and it is found to answer by many educational coaches who are experts in teaching against time. But at the Royal School of Mines the higher course in geology is apparently not required for the associateship either in mining or in metallurgy.

A FRENCH engineer has constructed an experimental internal continuous combustion turbine, with the combustion chamber lined with refractory material. Gasolene is fed through a nozzle from a compressor on the turbine shaft and mixed with air, electric lignition being used. The resultant temperature is 1,800 deg. C. (3,272 deg. F.). The gas given off impinges upon the turbine blades, which are kept cool by low pressure steam being generated in water jackets around the gas nozzle. This turbine is said to have shown an efficiency of 18 per cent., and improvements now being made in the compressor are expected to bring this figure above 25 per cent.—*Exchange.*

ON THE MEASUREMENT OF AIR FLOWING INTO THE ATMOSPHERE THROUGH CIRCULAR ORIFICES IN THIN PLATES AND UNDER SMALL DIFFERENCES OF PRESSURE.

By R. J. Durley, Montreal Canada.

(*Concluded from the September issue.*)

29. The method used in making the trials was as follows:—The reservoir was pumped up and the valve between it and the compressor was then closed. Sufficient time was allowed for the air in the reservoir to come to a uniform temperature. The gate valve V, being open, the regulating valve V_2 was opened till the head of air in the box was brought to the point at which the trial was to be run. The gate valve was then closed and the chronograph switch thrown in so that when the valve was reopened a record of the time would be made. The initial pressure and temperature in the reservoir were then read and the trial started. The final temperature and pressure were not read immediately at the end of the trial as it was found that some time elapsed before the air in the reservoir had resumed a uniform temperature. The leak during this time was allowed for, but was very small since the pressure in the reservoir was low.

Accuracy of Results.

30. Upon consideration it was found that the effect of the errors shown in Table I upon the final result might cause a total possible error of about ±7 per cent. on the 5-16 inch orifice at 1 inch head, or of about ±1½ per cent. in the case of the 4 inch orifice at 4 inch head. The actual deviations of the observed results from the mean curves were found to be within these limits when allowance was made for the effect of the size of the gauging box on the results, as explained below.

31. The probable errors have been calculated for the various series of experiments made at different heads, and are,—

Head.	Probable error %
1 inch.	0.735
2 "	0.470
3 "	0.635
4 "	0.667
5 "	0.650

It seems permissible therefore to regard the figures ot Tables IV and V as being reliable to within less than 1 per cent.

Corrections for Barometric Pressure and Temperature.

32. From equation (3) it is seen that when the difference of pressure on the two sides of an oriffice is small, the weight of air discharged per second should vary directly as the square root of the mean pressure and inversely as the square root of the absolute temperature. In tabulating the results of the experiments made it was therefore necessary to reduce all the actual discharges, as measured, to their values at 60 degrees Fahr., and 30 inches barometric pressure. A special series of trials (Nos. 151-162) was made to see whether the actual discharge would vary as above with regard to temperature. For this purpose the air was passed through the heater (H, Fig.. 2) previously described, and was delivered to an orifice one inch diameter under a head of 3 inches of water, at a series of successively increasing temperatures. It was found during each experiment that the temperature in the gauging box could be kept constant within 1 degree Fahr., and the trials were made between the limits 55 degrees and 105 degrees Fahr. After measuring the actual discharge in each case, and correcting for barometric pressure, the mean line (Fig. 4) was drawn—and the corrected discharges tabulated from it. The figures for these trials are given in Table II, and show that within the limits of these experiments the discharge may be taken to vary inversely as the square root of the absolute temperature in the gauging box.

33. It was found impossible to make the numerous joints of the heater perfectly air tight. The air leaking out was, of course, visible in the water in the containing tank, its greatest amount was found to be about 0.000037 pounds per second and was allowed for in calculation, being measured by displacement in each case. The heater was not employed for the other trials and in them this source of error did not exist.

Calculation of Actual Discharge from Experiments.

34. Trials 1-146 were made with the temparature in the box as near 60 degrees Fahr. as possible, and variations from this temperature were allowed for, as mentioned above, on the

assumption that the discharge is inversely proportional to the square root of the absolute temperature. Proper correction for barometric pressure was also applied, and from these experiments the actual discharge was then calculated. The corresponding ideal discharge was also worked out from equation (4) for a temperature of 60 degrees and a pressure of 30 inches of mercury. The actual discharge per square foot of orifice was then computed for each experiment and the results plotted on Fig. (5). In Figs. (6) and (6a) are shown the values of the coefficient of discharge obtained from the curves of figure (5), and from the corresponding ideal discharges.

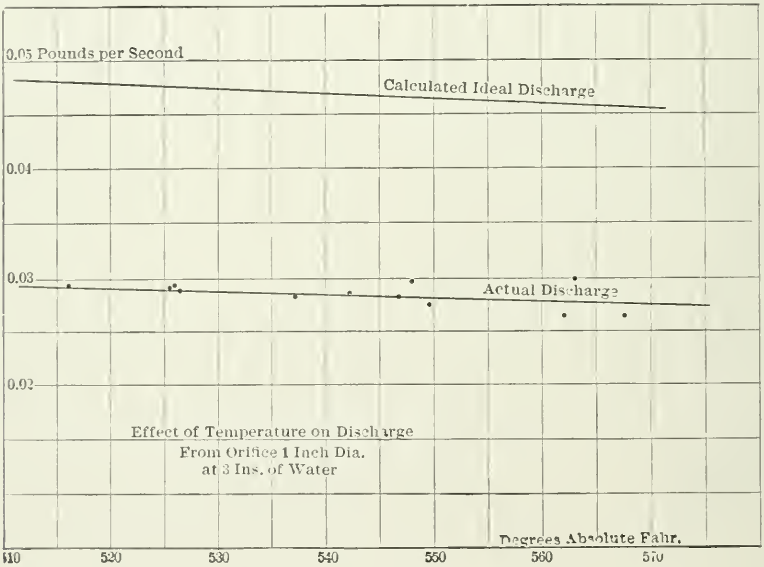


FIG. 4.

35. The volume of the reservoirs and attached piping being 91.881 cubic feet, it is readily shown that the weight actually discharged per second (if the pressure in the reservoirs changed from P_1 to P_2 pounds per square inch, and the temperature from T to T degrees Fahr., absolute, in t seconds), is given by—

$$W = \frac{248.3}{t}\left(\frac{P_1}{T_1} - \frac{P_2}{T_2}\right) \quad . \quad . \quad (5)$$

The actual discharge was in every case calculated by this formula from the observed quantities, corrections being applied as explained above.

36. With each orifice five sets of experiments were made at heads of from 1 inch to 5 inch of water. Figure eight shows for one orifice the corrected actual discharge and mean curve plotted on a base of difference of pressure. The mean curve was, of course, found by using the coëfficients of discharge of Figs. (6) and (6a).

37. Fig. (6) shows the curves of coefficients of discharge for various diameters of orifice plotted on a base of difference of pressure at orifice. From this diagram and from Figure (6a) can be selected a suitable coefficient for use in any particular case. The detailed results of the various trials are given in Tables VI to XVI.

Effect of Size of Gauging Box.

38. From the curves of Fig. (5), it was seen that the actual discharges of the larger orifices at the higher heads were considerably above the mean curve. This seemed to indicate that the results were being effected by the velocity of approach of the air. To check this, experiments (147–150 inclusive) were made with a 3 inch orifice at 1 inch and 5 inch heads, using a box whose area was only 13.8 times that of the orifice. The results of these trials were compared with those obtained from the same orifice in the large box and it was found that the discharge was 0.2 per cent. higher at the 1 inch head and 10 per cent. higher at the 5 inch head. This variation was greater than that observed from the trials of the 4½ inch orifice in the large box, the difference being due

to the smaller ratio between the areas of box and orifice. The curve of observed discharge from the 3 inch orifice in the large box, even at the highest heads experimented with, lies only very slightly above the curve of corrected discharge. These results show that the area of cross section of the gauging box should, for heads up to 5 inches, be at least twenty times the area of the orifice if reasonably accurate results are to be obtained. For greater heads a still larger box would probably be necessary.

Conclusions and Remarks.

39. The experiments and curves indicate that:—

(1) The coefficient for small orifices increases as the head increases, but at a lesser rate the larger the orifices, till for the 2 inch orifice it is almost constant. For orifices larger than 2 inches it decreases as the head increases, and at a greater rate the larger the orifice.

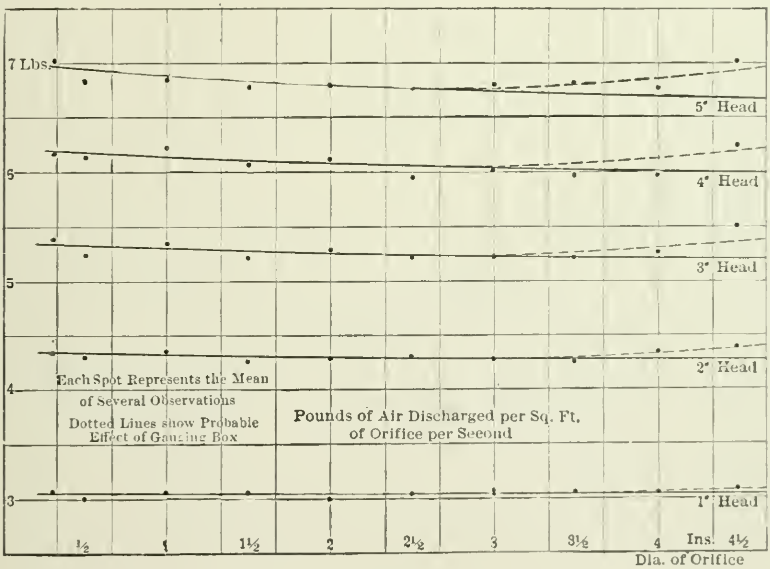


FIG. 5.

(2) The coefficient decreases as the diameter of the orifice increases and at a greater rate the higher the head.

(3) The coefficient does not change appreciably with temperature (between 40 degrees and 100 degrees Fahr.).

(4) The coefficient (at heads under 6 inches) is not appreciably affected by the size of the box if the ratio of the areas of the box and orifice is at least 20:1.

40. It is hoped that the information given in this paper will enable a reasonably accurate measurement of air at low pressure to be made by the use of a comparatively simple and inexpensive gauging apparatus.

NOTE.—On derivation of equation (1).

Let W = weight of gas discharged per second in pounds.

A = area of cross section of jet in square feet.

P_1, P_2 = pressures inside and outside orifice in pounds per square foot.

V_1, V_2 = corresponding specific volumes.

y = ratio of the specific heats K_p K.

K = Kinetic energy of 1 lb. of gas.

u = velocity of gas at any point.

T = absolute temperature.

If heat is given to a quantity of gas under any circumstances whatever, the amount of heat is equivalent to the increase in internal energy, together with the external work done, and thus, for any small adiabatic change.

$$K_v dT + PdV = 0 \text{ . . . . (a)}$$

Again, if there is no friction loss, the amount of heat given to the gas must be equivalent to the change in Kinetic energy, together with the change in pressure energy (head) together with the change in internal energy, so that for any small adiable change

$$dK + d(PV)\ K_v + dT = 0 \ ..\ \ ....\text{(b)}$$

From (a) and (b) we have

$$dK + VdP = 0$$

hence in passing from conditions $P_1 V_1$ to conditions PV we shall have

$$\int_0^u dK = \int_P^{P_1} VdP$$

r, since $PVy =$ constant, and if u is the final velocity,

$$\frac{u_2}{2g} = \frac{y}{y-1}\ (P_1 V_1 - P_2 V_2)$$

hence $u = \sqrt{2g \frac{y}{y-1} (P_1 V_1 - P_2 V_2)} =$

$$\sqrt{2g \frac{y}{y-1} \cdot P_1 V_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{y-1}{y}}\right]}$$

and the weight of gas discharged in unit time with frictionless adiabatic flow is

$$W = \frac{Au}{V_2} = A$$

$$\sqrt{2g \frac{y}{y-1} \cdot \frac{P_1}{V_1} \left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{y}} - \left(\frac{P_2}{P_1}\right)^{\frac{y-1}{\frac{+}{y}}}\right]}$$

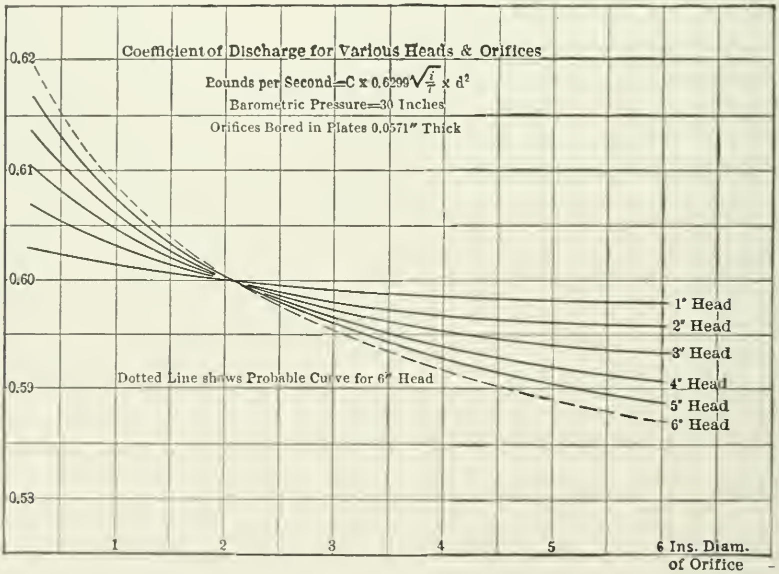


TABLE IX.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	RESERVOIR Abs. Pressure Initial.	RESERVOIR Abs. Pressure Final.	RESERVOIR Abs Temperature Initial.	RESERVOIR Abs Temperature Final.	Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
46	1½	1	572	91.8	44.8	524.1	519.5	519.0	.03870	.03839
47	"	1	592	94.8	44.8	538.3	518.8	519.3	.03772	.03732
48	"	1	586	94.8	44.8	541.3	519.5	519.7	.03773	.03734
49	"	2	417	94.8	44.8	540.8	515.5	518.0	.05274	.05224
50	"	2	600	94.6	26.6	523.4	517.0	513.4	.05368	.05301
51	"	2	600	94.8	26.8	523.2	515.7	514.5	.05318	.05256
52	"	3	373	96.8	44.8	523.7	512.7	516.6	.06500	.06440
53	"	3	319	89.8	44.8	523.4	512.8	516.7	.06570	.06514
54	"	3	339	92.8	44.8	529.4	513.1	516.1	.06459	.06399
55	"	4	286	91.8	44.8	523.8	512.1	516.2	.07632	.07565
56	"	4	306	94.8	44.8	526.9	512.2	514.9	.07518	.07444
57	"	5	273	94.8	44.8	524.7	511.1	517.1	.08480	.08415
58	"	5	267	94.8	44.8	532 0	511.6	515.2	.08445	.08326
59	"	5	256	91.8	44.8	527.7	512.1	514.8	.08401	.08321

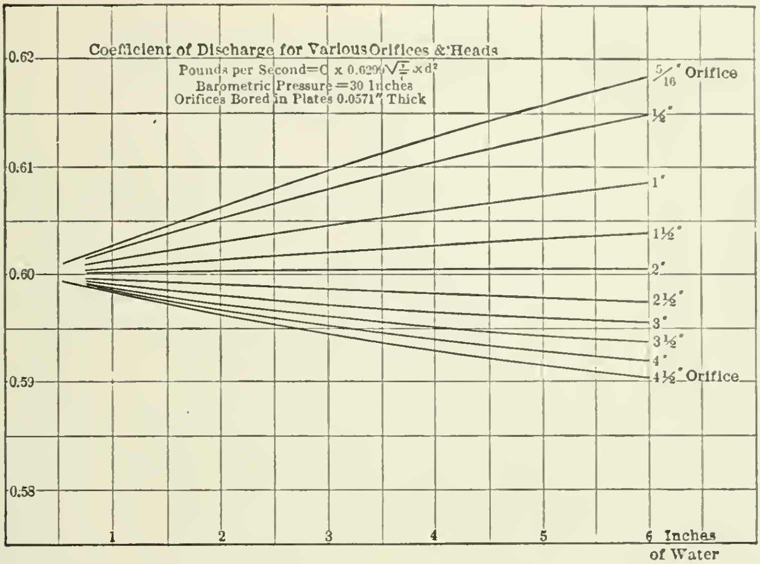


TABLE X.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	RESERVOIR Abs. Pressure Initial.	RESERVOIR Abs. Pressure Final.	RESERVOIR Abs. Temperature Initial.	RESERVOIR Abs. Temperature Final.	Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
60	2	1	347.2	92.1	42.5	524.6	510.1	511.0	.06613	.06521
61	"	1	332.0	87.0	37.5	539.8	510.6	513.2	.06579	.06503
62	"	1	335.2	87.0	37.5	536.4	512.8	513.7	.06613	.06539
63	"	2	240.5	82.0	32.6	537.2	511.4	513.0	.09191	.09097
64	"	2	242.0	87.0	37.5	525.5	511.5	517.1	.09479	.09416
65	"	2	232.7	94.8	44.8	534.5	511.3	521.2	.09632	.09600
66	"	3	240.0	95.8	36.0	526.2	516.4	512.6	.1165	.1153
67	"	3	240.0	94.8	35.3	525.6	522.3	513.3	.1168	.1157
68	"	3	240.0	91.8	32.4	525.5	520.1	514.7	.1165	.1155
69	"	3	210.0	93.1	41.1	526.2	524.1	513.6	.1167	.1156
70	"	4	150.0	89.3	45.7	525.5	523.9	514.4	.1371	.1358
71	"	4	150.0	88.8	45.9	526.0	521.9	514.9	.1343	.1333
72	"	4	150.0	96.6	53.8	527.3	519.7	515.0	.1322	.1312
73	"	5	119.31	92.2	54.3	523.3	521.4	517.5	.1502	.1494
74	"	5	113.93	90.6	54.6	524.6	523.0	516.1	.1491	.1481
75	"	5	132.18	96.8	55.1	524.5	522.2	514.3	.1489	.1476

TABLE XI.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	RESERVOIR Abs. Pressure Initial.	RESERVOIR Abs. Pressure Final.	RESERVOIR Abs. Temperature Initial.	RESERVOIR Abs. Temperature Final.	Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
76	2½	1	299.8	92.8	26.5	523.7	515.6	516.1	.1042	.1034
77	"	1	300.0	93.8	27.4	523.2	515.0	513.3	.1046	.1036
78	"	1	299.5	92.9	25.9	522.8	516.1	511.9	.1059	.1047
79	"	1	300.0	93.3	26.6	524.9	514.0	511.1	.1046	.1034
80	"	2	139.0	90.6	48.1	516.7	515.5	510.7	.1470	.1453
81	"	2	150.0	90.38	42.92	521.1	515.8	513.6	.1499	.1486
82	"	3	178.2	92.1	22.3	532.8	506.8	509.8	.1800	.1780
83	"	3	105.0	87.5	48.4	513.8	515.3	512.8	.1810	.1793
84	"	3	110.0	89.93	48.15	522.2	518.1	512.3	.1793	.1776
85	"	4	126.6	92.1	32.6	545.8	509.2	511.5	.2059	.2038
86	"	4	99.0	90.96	47.33	521.5	514.6	514.7	.2074	.2059
87	"	4	98.66	86.0	42.8	523.4	516.9	512.9	.2058	.2039
88	"	5	111.4	89.0	32.6	526.0	507.7	513.8	.2346	.2328
89	"	5	114.8	92.1	32.6	537.1	509.7	509.1	.2335	.2306
90	"	5	115.8	96.7	36.5	537.3	508.7	505.8	.2327	.2290

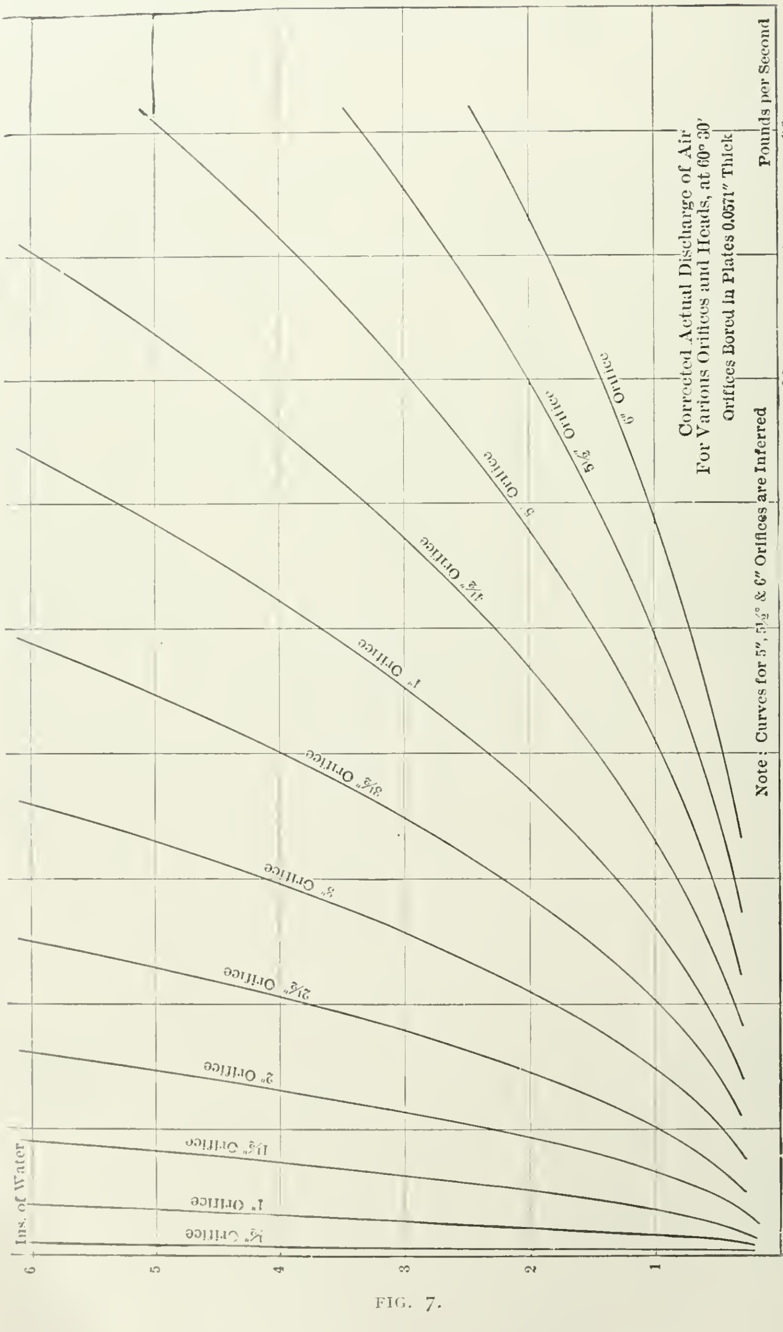
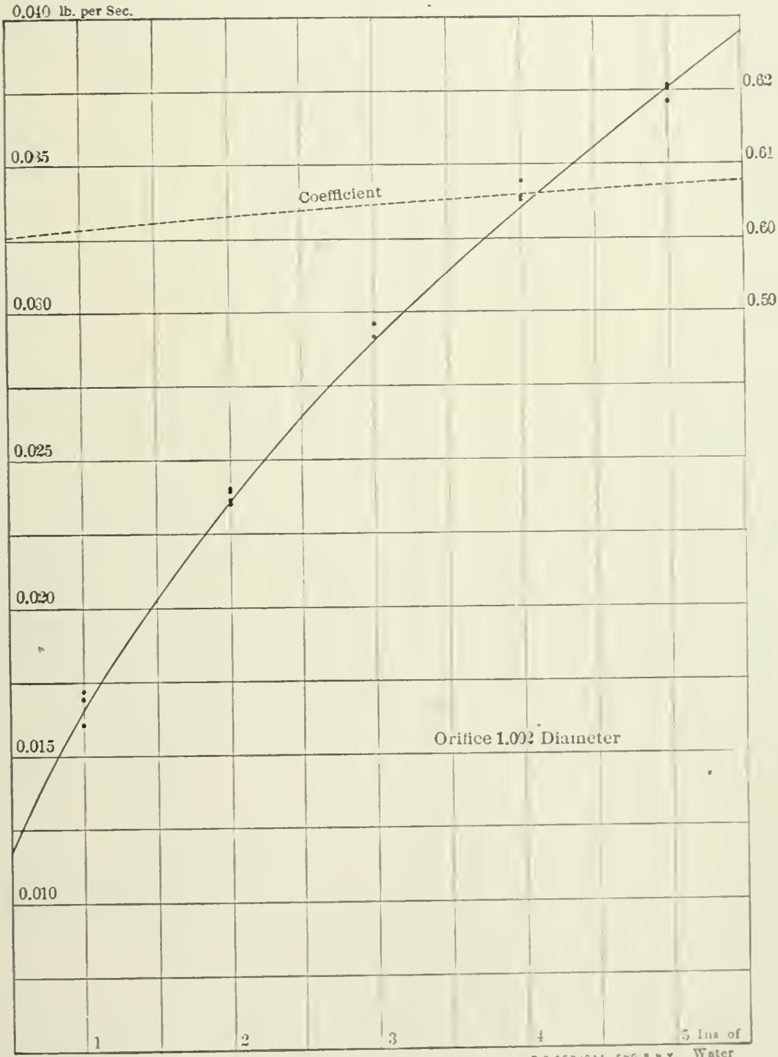

Corrected Actual Discharge of Air
For Various Orifices and Heads, at 60° 30'
Orifices Bored in Plates 0.0571" Thick
Note: Curves for 5", 5½" & 6" Orifices are Inferred
Pounds per Second
Ins. of Water
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2
3
4
5
6
6" Orifice
5½" Orifice
5" Orifice
4½" Orifice
4" Orifice
3½" Orifice
3" Orifice
2½" Orifice
2" Orifice
1½" Orifice
1" Orifice
½" Orifice

FIG. 7.



R. J. Durley

R.D.SERVOSS, ENG R, N.Y.

FIG. 8.

TABLE XII.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressure		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
91	3	1	150.17	98.3	49.6	524.4	521.2	513.2	.1530	.1513
92	"	1	148.32	96.5	48.5	524.4	522.8	513.8	.1532	.1513
93	"	1	153.63	95.9	45.8	526.6	523.0	512.1	.1531	.1509
94	"	2	86.21	92.1	53.1	523.9	523.6	513.5	.2147	.2111
95	"	2	93.72	93.0	50.8	519.0	517.4	512.6	.2138	.2107
96	"	2	74.95	93.2	59.3	520.0	519.3	509.9	.2161	.2114
97	"	3	67.32	99.1	62.0	519.9	517.6	509.3	.2613	.2567
98	"	3	73.20	94.0	53.6	520.3	519.5	512.5	.2638	.2591
99	"	3	44.45	99.2	73.7	521.8	511.4	509.5	.2569	.2533
100	"	4	47.92	94.8	63.0	519.8	508.8	509.3	.3043	.3006
101	"	4	45.54	97.1	68.3	519.2	517.0	511.5	.2995	.2944
102	"	4	55.15	100.7	65.6	521.8	517.5	509.7	.2986	.2941
103	"	5	42.97	90.0	59.3	519.3	516.9	510.4	.3388	.3336
104	"	5	50.23	98 0	62.4	520.1	518.8	505.7	.3373	.3292
105	"	5	43.27	94.6	63.1	518.8	518.6	506.3	.3490	.3397

TABLE XIII.

No. of trial	Diam of Orifice ins.	Head ins. water	Duration of trial. Secs.	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressure		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
106	3½	1	72.10	99.5	67.6	520.2	518.7	505.5	.2105	.2051
107	"	1	67.35	98.5	69.1	519.6	517.6	505.7	.2069	.2020
108	"	2	52.2	100.4	68.7	520.4	518.9	505.2	.2889	.2810
109	"	2	68.78	99.1	56.8	520.1	518.1	503.7	.2926	.2862
110	"	2	54.59	98.3	64.9	520.3	519.7	505.1	.2926	.2847
111	"	3	41.04	96.23	65.60	519.8	517.9	507.2	.3541	.3458
112	"	3	69.2	89.7	38.3	522.5	512.1	509.2	.3481	.3442
113	"	3	75.0	89.0	32.2	520.0	515.5	511.2	.3543	.3509
114	"	4	34.04	98.33	69.28	521.5	519.6	505.7	.4042	.3945
115	"	4	60.5	86.9	34.9	520.3	515.7	503.5	.4084	.4012
116	"	4	68.5	90.9	32.4	521.0	511.8	506.4	.4039	.3984
117	"	5	29.35	95.15	66.21	519.2	513.1	507.0	.4595	.4518
118	"	5	30.12	95.41	65.94	520.3	519.2	506.6	.4650	.4545
119	"	5	31.22	97.69	66.92	520.7	520.1	505.1	.4702	.4572

TABLE XIV.

No. of trial	Diam. of Orifice ins.	Head ins. water	Duration of trial. Secs.	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F, and 14.7 lbs.
				Abs. Pressure		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
120	4	1	54.89	98.00	66.57	520.6	518.9	507.8	.2715	.2657
121	"	1	48.69	96.56	68.56	522.0	519.3	506.7	.2745	.2684
122	"	1	47.46	97.30	70.03	521.6	518.3	506.6	.2696	.2642
123	"	2	36.08	96.31	67.24	521.1	520.0	505.4	.3820	.3722
124	"	2	38.60	97.39	65.60	521.6	518.9	505.2	.3887	.3805
125	"	2	40.6	97.15	63.73	520.8	517.0	507.7	.3880	.3811
126	"	3	53.5	89.6	37.1	523.7	519.7	508.3	.4636	.4578
127	"	3	54.6	91.8	37.2	524.3	514.5	506.8	.4684	.4620
128	"	4	22.69	94.65	69.07	521.4	518.6	504.8	.5319	.5189
129	"	4	21.66	95.49	70.63	521.4	517.0	503.6	.5330	.5191
130	"	4	42.5	91.2	43.0	524.3	514.8	506.0	.5298	.5221
131	"	5	19.91	96.55	71.33	520.5	519.1	503.7	.6125	.5970
132	"	5	20.32	97.35	71.17	519.8	518.7	503.4	.6135	.5967
133	"	5	20 68	93.94	67.75	520.1	516.4	504.6	.5943	.5819

TABLE XV.

No. of trial	Diam. of Orifice ins	Head ins. water	Duration of trial. Secs.	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressure		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
134	4½	1	38.00	97.85	69.83	521.0	519.4	504.8	.3489	.3406
135	"	1	47.83	102 48	66.96	525.5	518.9	507.3	.3429	.3373
136	"	1	40.25	97.13	67.37	520.9	518.9	506.2	.3505	.3438
137	"	2	23.57	99.0	74 6	522.1	518.9	506.2	.4834	.4727
138	"	2	25.89	93.50	65.77	515.9	512.7	505 4	.5086	.4984
139	"	3	23.79	96.31	65 18	515.7	512.9	503.8	.6233	.6085
140	"	3	25.65	97.74	64.40	515.4	516.0	503.4	.6295	.6099
141	"	3	23.82	95.77	64.77	515.0	515.8	503.4	·6308	.6119
142	"	4	21.46	96.82	64.62	515.3	515.4	503.5	.7247	.7044
143	"	4	21.31	94.35	63.30	515 2	515.8	503.4	.7052	.6832
144	"	4	37.00	94.47	39.95	515.1	514.5	498.9	.7112	.6925
145	"	5	29.06	93.40	44.37	515 9	515.0	498.2	.8121	.7902
146	"	5	29.71	93.43	44.80	515.9	516.3	496.5	.7893	.7664
147	3	1	93.85	96.61	65.90	520.2	517.9	509.1	.1548	.1512
148	"	1	87.81	97.21	68.31	521.1	519.0	508.0	.1556	.1515
149	"	5	36.59	92.35	63.41	520.2	518.1	504.7	.3767	.3675
150	"	5	34.74	91.02	63.41	520.3	519.8	504.4	.3796	.3679

TABLE XVI

No. of trial	Diam of Orifice ins.	Head ins water	Duration of trial. Secs	Reservoir				Box Temp. Abs.	Actual discharge Lbs. Sec.	Corrected actual discharge at 60° F. and 14.7 lbs.
				Abs. Pressure		Abs. Temperature				
				Initial.	Final.	Initial.	Final.			
151	1	3	1,020	91.3	27.5	522.6	518.2	516.1	.02968	.02938
152	1	3	600.0	93.9	55.9	525.4	517.9	525.5	.02936	.02901
153	1	3	600.0	87.2	49.1	526.3	517.4	525.9	.02936	.02934
154	1	3	600.0	94.2	56.1	527.5	517.8	526.3	.02916	.02881
155	1	3	600.0	90.6	52.6	531.7	519.1	537.0	.02861	.02827
156	1	3	600.0	89.3	52.2	524.0	519.3	542.4	.02898	.02864
157	1	3	600.0	87.6	50.5	525.6	518.0	546.8	.02865	.02832
158	1	3	600.0	92.1	52.0	531.8	517.7	548.1	.03018	.02984
159	1	3	599.5	86.3	50.2	524.8	518.4	549.6	.02803	.02767
160	1	3	599.0	90.6	55.1	533.5	522.4	561.8	.02675	.02637
161	1	3	600.0	91.8	51.5	531.3	517.3	563.3	.03038	.03004
162	1	3	599.4	80.0	46.0	523.7	520.1	567.6	.02671	.02636

ELECTRICITY AND COMPRESSED AIR.

What is technically known as the electro-pneumatic switch has been installed at the Newcastle Central Railway Station, Newcastle, England, for the purpose of dealing with the traffic at the west end of the station, which will be considerably increased when the new High Level Bridge is opened.

The necessary plant for working the system has been laid down under the north wing of the old High Level, and the new order of things is expected to come into operation in August.

One of its advantages is that manual exertion is reduced to a minimum. All the signalmen will be required to do to change the position of points or signals will be to shaft a small lever, which can be freely worked with the finger and thumb. Compressed air will do the remainder.

The plant comprises two 35 horse-power gas engines, with combined air compressers, and a 30 horse-power electric motor, also fitted with a combined air compresser.

These generate the compressed air by which the points and signals are worked, provision being made for storing the electricity for setthe air in motion.

At the west end of the station a new signal box has been erected from which will be manipulated 182 signals and 136 pairs of points by 211 levers. In many cases a single lever works two and more signals and points. 83 levers to be installed will command 60 south end of the new High Level, and the A signal cabin has also been built at the signals and 34 pairs of points and bars.

Pipes are to be laid from the signal boxes to the points and signals, and a uniform pressure of 65 pounds of compressed air will be maintained, the working of the motive power being done electrically by connect on with the levers.—*Exchange.*

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., . Managing Editor
P. F. KOBBÉ, JR, . . Business Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. OCTOBER, 1906. No. 8.

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THE EDUCATION OF ENGINEERS

We print in this issue of COMPRESSED AIR an abstract of a paper read recently before the Institution of Mining Engineers at London, on "The Education of Mining Engineers," in which many important subjects are taken up relative to obtaining the most advantageous curriculum. Now we note that not one word is ever said about compressed air as being a subject of study in papers such as this, and, with one exception, we do not know of any college of university in the United States or England which gives courses in this subject. The one exception is New York University, where a comprehensive course in compressed air and its applications is delivered by Prof. D. W. Hering of the Department of physics. Why is it that this important subject has received so little attention from our colleges and scientific schools? The field of compressed air is an exceedingly broad one and would certainly justify the establishing of such a course.

The capital involved in the manufacture of compressed air machinery is very great and, while not perhaps so large as that involved in the manufacture of electrical apparatus, it is still a big factor in our industrial system. When a branch of engineering supports such large concerns as the Ingersoll-Rand Co., Chicago Pneumatic Tool Co., Sullivan Machinery Co., and many other concerns of prominence, it seems to us that it should receive attention in our colleges and technical schools. Such is not the case, however, and, while many colleges are devoting months and even years to the subjects of electricity and direct combustion engines, compressed air is entirely neglected.

For this reason, when the young technical graduate takes a position with any of the companies such as mentioned above, he has to spend many months of hard study before he is fitted for an important position; while, if a short course were given on the theory and practice of compressed air, much time and trouble would be saved later on. A short time ago we printed an article on the training of apprentices at the shops of the Rand Drill Company, at Tarrytown, N. Y., in which the writer stated that six months were required for these young engineers to learn the rudiments of their chosen profession, and it was necessary that the knowledge gained by experience in the shops be supplemented by numerous lectures and examination questions before the apprentice was deemed of sufficient value to receive a position in one of the branch offices of the company. Even then, however, his education was not complete and it required at least two months more to become familiar enough with compressed air theory to be trusted with the "figuring out" of a plant. We certainly hope that some of our universities will establish courses in compressed air and follow in the foot-steps of the New York University in training young men for this most important subject.

ARE WE BEING SUPERSEDED?

For ten years Compressed Air has harbored the impression that it was secure in its chosen field, thus far nothing having been perfected to take its place. Electricity has given us a few spasms now and then, but the fright soon passed off leaving us more secure than ever. Now, however, we receive word that a new medium for the transmission of power is coming to the front. One of the latest monographs of the United States Geological Survey is devoted to what is in a certain sense a new industry. This is nothing less than the extraction from the earth of natural carbonic acid gas. Beneath the surface of the earth in and near Saratoga, for instance, is an immense reservoir of carbon dioxide, and the business of utilizing its contents, independently of the bottling of the waters for which that locality has long been famous, is now conducted on a large scale. The daily output of the gas wells is not far from twenty thousand pounds, and fully half that amount is recovered and marketed, first going through a process that robs it of its moisture and then being highly compressed for shipment in steel cylinders.

The most interesting point in connection with the use of this gas, says the report, is that in some localities its service is by no means limited to the production of soda water and the imparting of effervescence to other beverages. The compressed gas being used in place of compressed air for the operation of block signals on railways, possibly because it is more economical in some localities to rely on cylinders of gas than to install a compressor plant. Again in Europe it is employed more extensively than in the United States for mechanical refrigeration. The machinery in which it is used is more compact than that required with ammonia. Pressures of 1,000 to 1,200 pounds to the square inch are deemed not only feasible but safe with carbon dioxide, while 150 to 200 pounds represent the common practice with ammonia. Besides, when an explosion suddenly liberates a large quantity of ammonia vapor the effect is often fatal to those in the immediate vicinity. No such consequences attend the escape of carbonic acid gas.

As a result of all these discoveries it would seem as though we ought to warn our subscribers that perhaps they may wake up some morning to find that the name of this paper has been changed from Compressed Air to "CARBONIC ACID GAS," "CARBON DIOXIDE," or plain "CO ."

LIVING IN COMPRESSED AIR.

The Royal Society has just issued a first report of some interesting experiments lately undertaken by two Englishmen of science, Dr. Leonard Hill and Mr. M. Greenwood, with a view to ascertaining the effects of compressed air on the human system. These experiments throw some light upon some obscure points in physiology, but they have a practical value altogether apart from their medical, or scientific, aspect.

It is well known that divers can not descend more than a certain depth below the surface of the water, primarily because the diving dress must have compressed air inside it in order to resist the pressure of water outside, and, roughly speaking, one atmosphere has to be forced in for every distance of thirty-four feet below the level of the water.

Thus, at a depth of 170 feet, a pressure of five atmospheres is necessary. Few divers, however, have ever descended so far. The record dive is 204 feet, but the unfortunate man who accomplished it paid for it with his life. At depths of about 100 feet a danger signal is usually hoisted. The British Admiralty adopt 120 feet as the limit of their operations, but this has been surpassed many times by men working for private firms.

There is much buried treasure, some of which is located on charts, but with our present appliances it is hopeless to attempt to recover any of it. Any improvement, therefore, in methods of diving is of considerable importance.

Dr. Hill explained that Mr. Greenwood and himself had been trying the effect of compressed air upon themselves, and for this purpose they had had constructed a large steel cylinder, of rather more than forty-two cubic feet capacity, with a moter-driven pump for compression and taps for letting out the air, or, as it is called, decompression.

They were subjected to a pressure of about five atmospheres, equivalent to a depth of 170 feet. Mr. Greenwood successfully resisted seven atmospheres, which meant that he could dive to a depth of considerably over 200 feet. They had previously tried experiments on various animals—dogs, cats, rats, mice and monkeys—and found that they could resist eight, nine, and even ten atmospheres.

As a result of their experiments they have ascertained that divers' deaths were due to the fact that the men were brought to the surface too rapidly. Time should be allowed for decompressure and all would be well.

Dr. Hill said his impression was that the functions of the body were normal in compressed air. They stayed in the apparatus four or five hours and measured their respiration, took notes of the state of the blood, and so forth.

Dr. Hill said that no doubt men would go far deeper in the future than they had done. It would certainly be less dangerous than looping the loop. They had a monkey who was subjected to eight atmospheres three times a week for four hours at a time, during a whole month, and he never had the slightest unfavorable symptom.

Dr. Hill's apparatus is a great boiler-like cylinder with a hole at the side scarcely bigger than the porthole of a steamer. Through this hole he creeps with considerable difficulty and lies at full length on a matress inside, while an iron clamp is fixed with great nuts screwed tight by a giant spanner. There is a small electric light inside, and communication is carried on with the inmate by means of a telephone.

NEW PUBLICATIONS.

Electrically-Driven Air Compressors.—Thompson.—A paper read before the British Institution of Mining Engineers on the use of electrically-driven air compressors at the Ouston Colliery. It was found at that mine that electricity at the coal face was out of question, owing to the amount of gas given off by the Busty seam. On the other hand, a well-equipped modern electric station had been put down at the pit. It was then concluded that it would be cheaper to utilize the plant for generating electric current to be transmitted to electrically-driven air compressors than to put down at the bank, in addition, a steam-driven air compressor plant and to conduct air to the face in the usual way. Moreover, electric cables can be placed in the shaft and along the roadways more easily than bulky air pipes. The installation is described; in two tests efficiencies of 62 and 60 per cent of the plant were found, which is thought to compare favorably with that of any steam-driven air compressor plant.

"The Abuses of Valves," published in *The Valve World,* by Mr. R. T. Crane, president of Crane Co., says that in 95 cases out of 100 leaky valves are due to abuse and carelessness on the part of the men who install them, rather than to defects in the valves themselves. If the few simple directions given by Mr. Crane for the installation and care of valves were generally followed much of the annoyance and expense due to leaky valves would be avoided. The article has been printed in the form of a poster suitable for hanging on the walls of engine rooms and shops, and all users of valves may obtain one or more copies free by writing Crane Co., Chicago. The posters are legibly printed in two colors on heavy calendered bristol board, and contain no advertising other than the name of the publisher.

TRADE PUBLICATIONS.

Sullivan Machinery Company, Railway Exchange Building, Chicago, Ill.—Modern Methods of Producing Coal. Part 1. A handsomely illustrated booklet, 6x9, devoted to descriptions of the Sullivan Pick Machine for undermining coal. This book also contains some valuable statistics on bituminous coal production in the United States, average prices per net ton, approximate analysis and heating value of American coals, etc. This catalog is known as Catalog No. 57.

Edison Manufacturing Company, Orange, N. J.—Illustrated booklet describing Edison Primary Batteries (formerly known as Edison-Lalande) and the Edison Spark Coil.

Cooper-Hewitt Lamp Company, Garrison Place and Fayette street, Pittsburgh, Pa.—The Economical Lighting of Industrial Plants. Booklet 5x7¾, describing the Cooper-Hewitt Mercury-Vapor Lamp as adapted to lighting manufacturing plants, offices, drafting rooms, etc.

The Nernst Lamp Company, Pittsburgh, Pa.—Booklet 6x9, illustrating the design and application of Nernst Lamps for Electric Lighting.

Steel City Electric Company, Third street and Pennsylvania avenue, Pittsburgh, Pa.—Small booklet devoted to Star Bushings and other contractor's supplies.

Baldwin Locomotive Works, Philadelphia, Pa.—Record of Recent Construction, No. 56, being a description of the Atchison, Topeka & Santa Fe Railway System and the locomotives constructed for this system by the Baldwin Locomotive Works since 1875.

Western Wheeled Scraper Company, Aurora, Ill.—Profusely illustrated catalog describing Standard Western Wheeled Scrapers, Drag Scrapers, Railroad Plows, Road Machines and Ditchers, Western Air Dump Cars, etc. This catalog is submitted by M. E. Davis, Eastern Agent, 829 Park Row Building, New York City.

Kilbourne & Jacobs Manufacturing Company, Columbus, Ohio.—Catalog No. 32-D describing Contractors' Dump Cars, Steam Shovel Cars, Hopper Cars, Track Laying Cars, Quarry Cars and Contractors' Dump Carts.

CHEAP oxygen is the one important product thus far obtained from liquid air, for which such extravagant prophecies have been made. As the nitrogen and oxygen of the liquid air return to the gaseous state, at different temperatures, it has proven to be possible to separate them by fractional distillation, and as the evaporation of the gases cools the air entering to be compressed in the apparatus, the process is very economical. An idea of this efficiency has lately been given by M. Georges Claude. His plant produces 1,000 cubic metres of oxygen with a purity of 96 to 98 per cent. in 24 hours, and the cost in France is only one-twentieth of that of oxygen from the electrolytic decomposition of water.

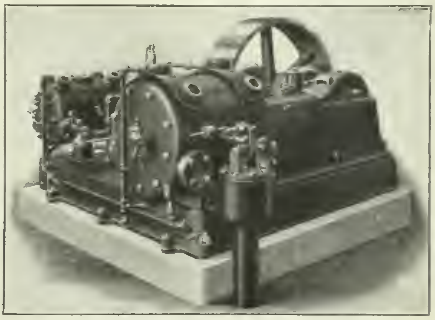
The use of underground compressors obviates a loss by friction in transmission and also makes possible a saving in labor, as the man in charge can also attend to other duties. There is sometimes a disadvantage in that the air compressed may be foul and therefore unfit for ventilation at the headings. Every mining engineer must be his own judge as to the desirability of an underground compressor for his particular case—*Mining Reporter*.

Newport, R. I., July 25. A whitehead torpedo fired from the dock at the torpedo station during practice to-day struck and sank a hole in the boat a distance of three hundred seated. A life boat rescued the seamen. The torpedo was not charged, but it was driven with sufficient force by compressed air to break a hole in the boat a distance o fthree hundred yards. The men in the boat were standing on the range to pick up the spent torpedo.

INDUSTRIAL.

A NEW AIR COMPRESSOR.

The accompanying engravings illustrate a new type of Sullivan air compressor, which is particularly suited to the requirements of mines and quarries, as well as for industrial purposes of various kinds. This machine is of the duplex pattern, and is built in several combinations of steam and air cylinders, also for belt and power drive. The dominant feature of these various types is the box frame, with housing, which forms a tight enclosure about the crank discs, main bearings, eccentrics, connecting rods and crossheads. This housing excludes dust and dirt, and permits the use of a system of self-lubrication of the principal working parts. As shown in the sectional view, an oil well is provided in each frame, in which the lower edges of the crank discs are immersed. The oil clinging to the discs is removed by scrapers in contact with their upper edges, and thence conveyed, by means of a storage chamber and suitable pipes, to the main journals, crank pins, eccentrics and cross-head guides, being finally returned to the well by gravity to be used again. These machines require the minimum of attention and care, as it is necessary to add oil to the wells only at long intervals.



EXTERIOR VIEW OF NEW SULLIVAN AIR COMPRESSOR.

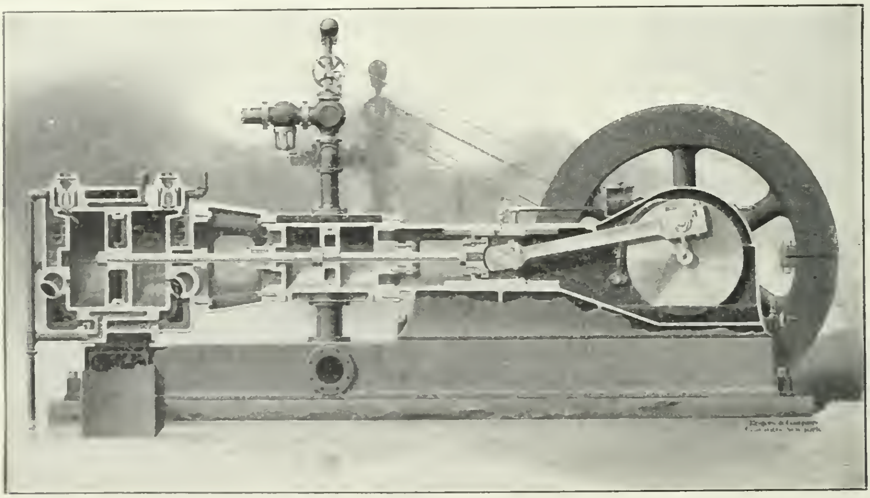
These compressors are very compactly and substantially built. All sizes except those of largest capacity are mounted on a heavy subbase, in which the inter-cooler and steam reheater (on cross-compound machines) are situated. The frames are of the heavy duty type or tangye pattern, with long bearings on the base, securing rigidity, and maintenance of correct alignment of working parts. The steam valve gear is controlled by a Meyer adjustable cut-off. the throttle being regulated by a sensitive steam and air governor.

The air cylinders are not cored out. but instead. separate liners are forced into the castings. thus precluding shrinkage strains. The space between the liner and the cylinder forms the water jacket. and outside of this again is the air inlet passage. Incoming air is thus admitted to the cylinder without contact with heated walls.

The air cylinder heads are also water jacketed, and in two-stage compressors. an efficient inter-cooler is provided. consisting of a nest of cold water tubes. made of copper. with whose cold surfaces the air is forced to come into intimate contact in passing from the low to the high pressure cylinder.

The inlet valves on all air cylinders are of the semi-rotary or Corliss type. and are moved by steel valve stems, connected by adjustable connecting rods to independent eccentrics on the engine shaft. The moving parts start from and arrive at the ends of their travel with a slow and easy motion. but at the points of opening and closing of the valves, these parts attain their greatest speed; it is thus possible for the valves to remain open during the entire stroke, allowing the cylinder to fill with air at barometric pressure. and trapping it instantly before the piston begins its return.

The valves themselves are made of close-grained semi-steel, of large diameter. fitted with accuracy. Provision is made to permit a thin film of air to get behind the closed valve. pressing the cutting edges to the seat, and making the valve tight against leakage. The valve stems have T-shaped heads on their inner ends, carefully planed and fitted to the slots in the ends of the valves. The attachment is such that the valves are free to follow up wear automatically without hindrance from the stems. These valves may be removed through the back bonnets without disturbing the setting of the valve gear. This valve gear is simple. strong and durable. is positive and reliable in action. and insures high volumetric efficiency.



SECTIONAL VIEW OF NEW SULLIVAN AIR COMPRESSOR.

The discharge valves are placed radially on top of the cylinder head castings. They are set with removable seats in shallow ports or pockets, as shown in the sectional view of the class WE machine referred to above. at a sufficient distance from the ends of the cylinder so that the piston travels completely past the openings to these pockets. at each end of the stroke, thereby reducing clearance to the smallest amount possible. These valves are of poppet type, internally guided on cast iron plugs and held to their seats by light steel springs. They are seated in bronze cages, readily removable by unscrewing the valve plug. As shown by the sectional view. they are completely surrounded by water jackets. in order to reduce the temperature of the air at its terminal pressure.

All working parts are constructed of materials which experience has shown to be best suited for their respective purposes, and all parts of the machines are readily accessible for inspection or repair.

These air compressors are built in capacities ranging from 100 to 2,600 cubic feet of free air per minute. The makers, the Sullivan Machinery Co., of Chicago, state that they have erected large additions at their works at Claremont, N. H., for the proper manufacture of this type of compressor.

THE Sierra Consolidated Gold Mining Co., of Millsboro, N. M., has placed a large contract with the Traylor Engineering Co., of New York, for hoisting, pumping and electrical machinery, and the steel and iron work necessary for a complete hoisting and crushing plant, thus completing its outfit for taking out and treating its ores.

The order was placed through the Hon. Warner Miller, president of the company, from the New York office, 100 Broadway. The hoisting outfit is for a three-compartment vertical shaft, and there are to be two electric hoisting engines; one with a single drum to hold 1,000 feet of ⅝″ wire rope, to lift 2,000 pounds at a rate of 300 feet per minute, and the other with two independent drums, each to hold 1,000 feet of 1″ rope, and capable of lifting a load of 4,000 pounds at a rate of 500 feet per minute. The hoists are to be fitted with all the latest appliances for safety and convenience, and will be operated by 3 phase, 60 cycle, 220 volt, variable speed, external resistance, induction motors.

A complete electrically operated pumping plant is also included in the contract. This will require 17,000 feet of transmission wire to connect it with the power house, besides an entire equipment of piping, valves and other fittings. The current for operating the machinery will be generated by two 125 Kilowatt revolving field Generators, of the "Water Wheel" type, each one direct connected to a 170 H. P. American Diesel oil engine. The two Diesel engines and the generators are included in the contract. Other electrical equipment furnished by the Traylor Engineering Company will be, two 12½ Kilowatt, 125 volt, direct current generators: five 30 H. P., 200 volt motors, with auto-starters; one 15 H. P., 200 volt motor, with auto-starter; three Kilowatt step-up transformers for raising the line current voltage from 200 to 2,000 volts; three similar step-down transformers for reducing the line voltage from 2,000 to 200 volts; a complete switchboard, lamps for the mill, and the wire and other materials for the 17,000 feet of transmission line. The contract includes also a cage, skips, grizzley, ore bin gates, steel linings for the ore bins, a plunger feeder, a belt conveyor 100 feet long for taking ore from the crushing plant to the stamp mill bins, sheave wheels, an amalgam box and two steel tanks, one of about 96,000 gallons capacity, and the other of about 16,000 gallons.

THE Canadian Westinghouse Co., Ltd., is being called upon to supply apparatus for the operation of a number of single phase railway lines. A recent contract is for furnishing their latest type of alternating current single phase railway equipment for approximately 35 miles of track, for the Windsor, Essex & Lake Shore Rapid Railway Co. For the present, five cars equipped with two 100 H. P. motors each, will be operated, in addition to which the order covers a 500 K. W., single phase, 25 cycle generator to be installed in the main power house near Essex, together with switchboards, exciters and transformers, for operating the system. A trolley voltage of 6,600 will be used and the most improved type of catenary line construction will be installed throughout the system.

The Stanley-G. I. Electric Manufacturing Company, of Pittsfield, Mass., have just placed on the market a new and novel form of induction motor made in various sizes up to 7½ H. P. The novel feature of this motor is in having the laminated iron core of the stator freely exposed to the air around its entire periphery. Because of the fact that the frame is held together by means of a riveted construction, the motor will be known as the riveted frame type. The cast-iron ribs which are used with the ordinary induction motors are entirely done away with and thereby all metal is used to much higher efficiency than ever before attained in induction motor design.

IT would be dangerous to attempt to operate a hoisting engine in lowering a bucket, skip, or cage, depending wholly on the air compressed in the engine-cylinder by the reciprocal movement of the piston to act as a brake without any other means of control. Engines are made having auxiliary cylinders set tandem with the engine cylinders and connected with the air-receiver of a compressor, but this style of brake arrangement has not become popular as yet. The best type of hoisting-engine control is the post-brake, though many believe the band-brake and the end-friction brake are equally safe. Some large hoisting engines have steam-brakes which are usually set unless the steam is shut off. These brakes operate automatically.

THE KONOMAX ROCK DRILL.

The "Johannesburg Star" of a recent date gives particulars of a new drill now working on the Village Main Reef, as follows: "The 'Konomax' drill is so styled because it gives the maximum economy in power. It uses considerably less air per blow than any other rock drill, while at the same time the blow is none the less powerful—in fact, it is more powerful. The blow is obtained from a piston stroke, during the whole of which the full air-pressure is maintained as the driving force, and as, owing to the shortness of the exhaust passage, back-pressure is reduced to a minimum, it will readily be seen that no other drill with the same size driving piston can be quite as powerful.

"The economy in compressed air is effected by utilizing the property of expansion on the return stroke. The degree of expansion, and therefore the extent of economy, is only limited by freezing difficulties. In the 'Konomax' drill, however, an expansion of 3 to 1 has been attained, this being due to two facts: (1) To the simplicity of the exhaust arrangements, which allow any particles of ice which may form to be quickly and safely evacuated. The valve-box is situated at the front end of the cylinder, and allows a perfectly straight and practically unobstructed exhaust. (2) The apparatus is itself, to a great extent, a reheater.

"The piston itself consists of two portions of different diameters, working in a corresponding double cylinder. The rear cylinder is considerably the smaller and is in constant and uninterrupted communication with the maximum air-pressure in the mains. The front cylinder, in which the larger piston effects the return stroke, is under pressure as regulated by the admission and cut-off air controlled by the varying position of the piston. The cut-off is arranged so as to give the requisite expansion and economical working of the driving-fluid.

"One advantage of the very greatest importance, which has been alluded to, results from the fact that no fluid-distributing device is employed in connection with the rear end of the cylinder, so that the operating valve is enabled to be located at the cylinder head, and the ports governed by the valve can, therefore, be made very short and practically straight. The weight of the 'Konomax' drill compares very favorably with that of any other rock drill of the same power.

"The handiness of the 'Konomax' drill is much superior to that of any other rock drill, owing to the fact that the short starting strokes, incidental to the commencement of a hole, are obtained with the piston at the front end of the stroke. Any practical rock drill man will appreciate this great advantage over the ordinary drill, in which, to obtain the short strokes, it is compulsory to have the piston at the rear of the cylinder, thus involving subsequent 'racking back' to lengthen the stroke. With the 'Konomax' drill the necessity of the 'racking back' is avoided, as the maximum length of stroke can be instantly obtained."

Construction work for the completion of the American Pneumatic Service system in the City of New York was recently begun. The present contract calls for 25 miles of double lines of eight-inch tubes connecting the General Postoffice (including the present system) with the Produce Exchange, Wall street, Madison square and Grand Central station at 42d street, thence extending north as far as 125th street. The lines over the Brooklyn Bridge to the Brooklyn Post Office are to be still further extended, under the new appropriation bill passed by the House of Representatives, between three and four miles. This will make the total system in Greater New York over 29 miles of double tubes.

The service in Boston, Chicago and St. Louis is pronounced an ideal one by the postal officials in these different cities and permits of local distribution and train connection simply unattainable by any other means, and this rapid despatch in their judgment is largely accounted for by this great new facility.

AGAIN a workman, this time in the Homestead Steel Works, has been killed by compressed air being forced into his body by a joking fellow-workman. It would seem to be wise for the makers of compressed air tools to suggest to every customer that he have notices posted about the works stating the danger of playing with or perpetrating practical jokes with compressed air, and that when these notices have been duly posted, those who continue to play with it should be held legally responsible for the consequences of their acts.

COMPRESSED AIR FORGES.

Although the great power and adaptability of compressed air have been known for a long, time, new applications have been produced very slowly. Only recently the Buffalo Forge Co. of Buffalo, N. Y., has perfected attachments for the use of compressed air in producing the blast in its portable riveting forges.

One such application is shown by accompanying Fig. 1. In this design the air is admitted by a needle valve through two brass nozzles into a cast-iron mixer nozzle, and thence direct into the tuyere. By the use of this needle valve the volume of air furnished is varied without affecting the pressure, and by such compounding as shown the volume of air required is reduced by one-half.

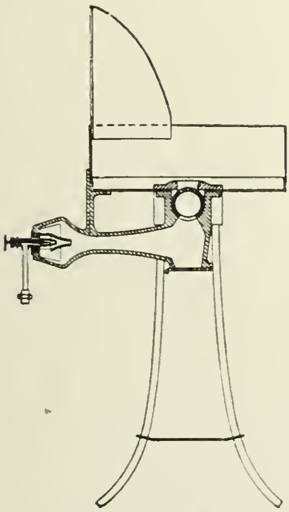


FIG. 2.—"BUFFALO" COMPRESSED-AIR FORGES.

Another application in which the compressed air acts directly upon the blast fan of the forge is shown by Fig. 2.

Extensive experiments show great economy in using the jet of air direct into the tuyere as described above, e. g., it takes one-ninth the amount of air to operate a forge in this manner that it does to operate the fan forge with compressed air (Fig. 2), and it takes one-fortieth as much as it does to operate the free-air forge with an ordinary blower. The pressure required is not high; in fact, very low pressures have been used advantageously.

The wide application of these forges for use on bridge and building construction, large railroad and repair shops, and, in fact, wherever compressed air is available, must be apparent to all, and the saving of time and labor in their usage, as well as the ease with which they may be connected by a small hose to the compressed air, should appeal to users everywhere.

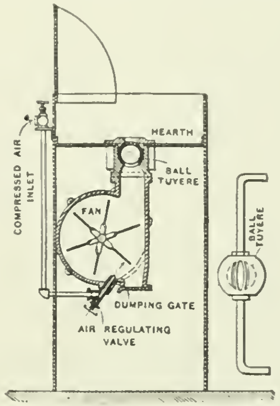


FIG. 1.—"BUFFALO" COMPRESSED-AIR FORGES.

Although the Buffalo Forge Co. makes both forges mentioned above, it recommends the compound compressed air operated on the injector principle (Fig. 1) because of greater simplicity, economy and more rapid heating.

The De La Vergne Machine Co., New York City, are installing at the E. & G. Brooke Iron Company's plant, Birdsboro, Pa., refrigerating machinery of 350 tons capacity, to be used in drying the air blast for their furnaces. Much interest has been aroused among blast furnace men by this new method in which the air is passed over coils of pipe containing cold brine or ammonia. Part of the moisture contained in the air is deposited on these pipes, the part remaining being practically constant so that the humidity of the blast is uniform. Among other important benefits derived from using a dry air blast of uniform humidity are improvements in the quality of iron and greater economy and efficiency in the operation of the furnace. Messrs. Frank C. Roberts & Co., Philadelphia, Pa., are the engineers.

JAPAN'S GROWING INFLUENCE IN CHINA.

Mr. Fraser, the British counsul-general at Hankow, warns the British public that the present foreign trade of Great Britain with China will only be maintained with the utmost difficulty. The spirit of opposition to foreign enterprise in the country, he says, is now manifesting itself among all classes of the Chinese people after a fashion that does not admit of two interpretations. The foreigner from the West is to no longer enjoy the privileged position in regard to land concessions or trade facilities to which he has so long been accustomed. Japan appears to figure considerably in this change of things. The Chinese former dislike for the Japanese, according to Consul Fraser, has been transformed into keen admiration, and the latter has now the advantage not only of his geographical position, but of his kinship and similarity in thought and custom, which particularly fit him for penetrating into the interior and pushing his wares in the shops and towns and villages of China whence no one ever visits a treaty port.

NEW PROCESS OF TURNING ORE INTO IRON AND STEEL.

D. H. Ross, Canadian commercial agent at Melbourne, reports that two Australian inventors have discovered a new process for the continuous treatment of iron ore, and he says that the results they have achieved are so successful that the process is to be exploited throughout the world.

It is called the Heskett-Moore process for directly converting iron ore into malleable iron or steel by a continuous system, and it is claimed effects a saving of 25 per cent. in the manufacture. The ore is simply concentrated by ordinary methods, or if it is magnetic it is separated electrically until the pure oxide of iron is obtained. The oxide of iron is passed through a revolving cylinder heated by waste gases from subsequent operations and brought in that cylinder to a dull read heat. It drops from the cylinder to a second similar cylinder, and in the latter it is brought into contact with the deoxidizing gas, which is forced through and brought into contact with the heated ore. The heated ore is thus converted into a pure iron. Accompanied by and protected by the deoxidizing gas, it is passed into a third chamber or melting hearth, where it falls into a bath of molten iron and is converted directly into steel or balled up as malleable iron.

The savings claimed for the process are those of time, labor—the whole process being automatic—fuel, and avoidance of flux. The inventors claim that they have discovered a direct method of producing steel from one operation instead of using the blast furnace and converter.

PRACTICAL ITEMS for PRACTICAL MEN.

THE following data relating to water will be found useful in making calculations for the capacity of pumps:

Cubic feet × 62 = pounds.
Pounds ÷ 62 = cubic feet.
Gallons × 8.33 = pounds.
Pounds × 0.12 = gallons.
Cubic feet × 7.5 = gallons.
Gallons × 0.134 = cubic feet.

These figures will vary slightly for different temperatures, but are sufficiently accurate for ordinary use.

In general underground work, the use of iron columns or bars, to which the rock-drill is fastened by clamps, slips, etc., is decidedly the best. The use of the single-screw bar or column in stopes, drifts, etc., of small dimensions is preferable. In large excavations the double-screw column, with swinging arm upon which the machine is mounted, is good, and has many valuable advantages auxiliary to cheap mining.

Cylinder cooling in the alcohol engine is considerably simplified as compared with cooling the cylinder of a gas or other type of internally fired engine by the fact that the flame of burning alcohol radiates heat less rapidly than that of gasolene or other internal-combustion fuels. Consequently less of the heat of combustion is communicated to the cylinder walls to be removed by the cooling jacket.

The most efficient way of dealing with scale is to prevent it from entering the boiler, which may be done by passing the water through a purifier. Here the water comes in contact with either exhaust steam or live steam from the boiler and its temperature is raised until the carbonates and sulphates are precipitated. The water then passes on to the boiler while the scale stays behind in the purifier, from which it may be removed without trouble. What scale gets into the boiler may be removed by blowing off.

To obtain a private water supply a deep well is often driven until a sufficient quantity is obtained. As the well is driven, an 8-in. pipe is sunk to form the casing. When the water-pocket has been reached the water will usually rise and stand in the pipe several hundred feet above its bottom, and the amount of water that can be usually pumped from such wells, without lowering the water, is practically unlimited. The cost of drilling deep wells per foot of depth including the casing, is for a well with 8-in. casing, $4.50 per foot.

Pneumatic locomotives are employed in some of the large German collieries. The engine is constructed like an ordinary steam locomotive. An air-storage tank takes the place of the boiler. The air is stored under pressure varying from 700 to 1,000 lb. per square inch. In some of the engines the air passes into an auxiliary reservoir before entering the cylinders. The air pressure is reduced to about 150 lbs. per square inch before entering the engine cylinder. The air is used expansively by means of the Stephenson link-motion gear. This system of underground haulage is cheaper and handier than rope haulage, and it is thoroughly safe and reliable.

In a wet mine, where a shaft is not conveniently available and it is desired to clear the workings of water, a bore hole may be driven to the surface of the water and a pipe driven far enough beyond to secure proper submergence; the water can then be lifted by means of compressed air. The expense of driving a shaft is thus saved and the water lifted at a comparatively low cost.

Compressed air is still more extensively used than electricity as the motive power for coal-cutting in Great Britain. In 1905 there were 555 compressed-air machines, while only 355 electric machines were in use. However, the latter are making greater strides than the former, for out of the year's increase in the number of machines in use, 85 were driven by electricity and 70 by compressed air.

The principal causes of loss in steam plants are the use of engines which are overloaded, undersized or badly arranged steam and exhaust pipes, and imperfect condition and poor operation of boilers. In many plants exhaust steam, which might be utilized for heating, is wasted. This is the most economical use which can be made of it; but if the back pressure be raised excessively to force the steam through the pipes, this advantage may be lost. To obviate this a vacuum system, taking only a small amount of power for its operation, should be used to draw the steam and water through the pipes.

The rate of air flow under a given pressure difference is proportional to the density or specific gravity of the fluid. A pressure of 1 oz. per sq. in. will create in the case of water only a sluggish stream. In the case of air, which is more than a thousand times lighter, the velocity will be as high as a mile a minute. For ventilation, this pressure and velocity are seldom exceeded, and efficiency of movement is sought in their reduction to the minimum consistent with the cost of the passage or conduit of greater area.

The rock-drill that performs the most work in the shortest time, at the lowest cost and consumption of air, and whose parts will stand the roughest usage, wear longest and are the least expensive to replace is the best machine to choose. The matter of first cost is not worthy of consideration, because an inferior rock-drill is a source of constant expense and serious loss, and when discovered should be immediately thrown out on the scrap heap.—*Engineering and Mining Journal.*

A new compound for pipe joints has been introduced in France. It is free from all the inconveniences of red lead. The new putty is composed of zinc gray and a Chinese vegetable oil utilized in England for manufacture of linoleum and some kinds of varnish. The material hardens completely at 150 deg. C., and at 110 deg. C. in six hours. This putty is said to be cheaper than red lead, and is of less density.

The air compressor and the rock drill have accomplished as much for the quarrymen as the magnetic needle did for the mariner or the tabulation of multiplication for the arithmetician. It has simply made easy what was before the impossible, and the end is not yet, for the improvements of pneumatic tools, for every branch of the stone industry are still advancing apace. It is indeed interesting to talk to the old-time quarryman who recalls the day when blasting was the only means for loosening the stone (with nearly every shot wasting fully 70 per cent. of the ledge broken off) and hear him relate vividly the actual comparison with modern quarry methods.—*Rock Products.*

CHIPPINGS.

ENOS Ayres, son of the well-known mining expert, H. R. Ayres, deceased, has joined the Traylor Engineering Co., as Engineer Salesman in the New York City district.

Mr. H. R. Ayres, during his lifetime, was known all over the Southwest as being one of the most successful and learned mining men in that part of the country, and his statement was enough to decide the method of treatment necessary for the recovery of all values possible from different characters of ores.

Mr. Enos Ayres has had the benefit of his father's training besides serving an apprenticeship in various mines and mills of Colorado and Utah. Mr. Ayres has had the advantage of a technical education, and is thoroughly competent to advise mining men as to what character of plant or machinery will successfully treat their ores.

Mr. Ayres will make his headquarters at the Company's offices, No. 114 Liberty Street, New York.

The shovel used in excavating the mass of the material removed in building the tunnel for the new Union station, at Washington, D. C., is operated by compressed air. By the use of these appliances all smoke and gases are avoided, allowing the workmen to perform their labors under the most favorable conditions without adding materially to the cost of construction. The remainder of this work consists of cut and embankment, with bridges over the intersecting streets. At the present rate of progress this work will be completed ready for use by the end of the year, though it has not been definitely decided when it will be put in service.

The object of piston valves originally was to take the place of large slide valves which could not be made tight and were therefore ineffective. In action the piston valve decreases the friction and increases the port opening for the same space occupied by the valve. A typical shape of a piston valve is a D slide valve wrapped in the form of a cylinder.

LIQUID AIR HIGHBALLS.

A story comes from London, by way of a special cable to the New York Sun, of liquid air as a substitute for ice in the concoction of cooling beverages. The process of liquifying air, it seems, has been so cheapened that it can be supplied for $1.25 a gallon, and a method of keeping it in a vacuum for seventeen hours has been devised. It is stated that a few drops in a highball will dance about like diamonds, give out a white mist, form into minute lumps of ice, and finally dissolve. The process takes about two minutes, at the end of which time the drink is deliciously cool. Patrons of the bar are advised, however, to wait for the liquid air to evaporate, lest the consequences be "pathetic" for themselves and "humorous" for the spectators. We should imagine that "tragic" and "shocking" would better fit the supposed situation. The stuff if something that cannot be fooled with to any great extent, being a candidate for honors with the buzz saw and the X-ray as resenters of undue familiarity. Still, liquid air, cautiously handled, may yet come into prominence as a club with which to smite the extortionate ice trust.

RAIL PRODUCTION.

An interesting review of the world's rail production appears in the last issue of *Engineering*. It shows that the annual rail production throughout the world is now estimated at 7,250,000 tons. In this aggregate American rails figure for 3,500,000 tons, British rails for 1,000,000 tons, German rails for 1,000,000 tons, Belgian rails for 350,000 tons, Russion rails for 500,000 tons, and French rails 300,000 tons. The odd 600,000 tons are made in Canada, Italy, Spain, Japan, China, Austria, &c. Even now it is by no means certain that the maximum output has been attained, as many countries are still developing their means of production. Our contemporary points out that during fourteen years ending 1894 the United States trebled their rail output. The rail production of Germany was also doubled in the same period; but this did not prevent Canada, Italy, Japan, Austria, &c., from making rapid progress in the same direction. The greatest consumption of rails appears likely to be now witnessed in Canada, British India, Australasia, and Africa. Russia has by no means completed her railway network; she has a territory double that of the United States, and her population exceeds that of the United States by some 70 per cent. But the political and economic condition of the Tsar's empire is just now by no means calculated to encourage fresh Russian railway enterprise. China will probably be a large consumer and possibly also an important producer of rails, as the Chinese authorities are giving considerable attention to the work of railway establishment. The same may be said of Japan.

PUMPS IN FRANCE.

Demonstration Needed to Secure Sales.

Consul-General Robert P. Skinner, of Marseille, reports that he has received requests from many correspondents in the United States for names of first-class firms in France who might be induced to take a general agency for American pumps and hydraulic machinery. The consul-general writes:

There are a number of such firms in this city, and I have communicated directly with several of them.

In each case it turns out that these houses already represent either American or French pumps, and therefore have no disposition to take on any other competing line. They could be interested, therefore, only if the American manufacturers visited this city, and demonstrated the superiority of their particular pumps. To discover properly equipped firms or individuals, not already engaged in this business, without the special knowledge which only manufacturers possess, is exceedingly difficult.

The information obtained in this connection merely confirms statements frequently made heretofore, namely, that attempts to build up an export business by correspondence and without the introduction of the personal element in the initial stages are rarely satisfactory. If my correspondents should visit this city, inspect local stocks, and visit innumerable firms and individuals whom I might mention, it is altogether probable that results would follow, but by an exchange of letters a successful issue is far less probable. There is a considerable demand for pumps on the part of shipbuilders at La Seyne and at Port de Boue, where the shipbuilding plants are located. In the city special pumps are required by manufacturers of chemical products and acids. Manufacturers of oils and soaps are also buyers of large pumps, the price of which approximate $570 put in place, this statement being too vague, of course, to convey any real information. There are, furthermore, in this region numerous coal, lead and bauxite mines and stone quarries, in all of which power pumps are required. As several of the standard American pumps are already on sale in this market, it goes without saying that other American firms would have no greater difficulties in overcoming the tariff rate of 25 francs per 100 kilograms ($4.82 per 220 pounds) on ordinary pumping machinery.

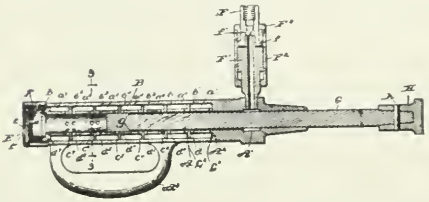
Some large steamers are now being built to be propelled by Curtis steam turbines. The cruiser Salem, for the United States navy, is 420 ft. long; displacement, 3,750 tons; designed speed, 24 knots; horse-power, about 16,000, 350 r. p. m. The Southern Pacific's Creole, 415 ft. 8 ins. long; displacement, 10,160 tons; designed speed, 16 knots; will require about 8,000 h. p.; revolutions, about 250. Her turbine will be one-half the weight of engines.

A pecularity about the farmers of Wuhu, China, is that they will accept in payment for rice and other products only Spanish dollars dating back to the last decade of the eighteenth and early nineteenth centuries. These dollars, although in purity no better than, and in weight not equal to, the Mexican, are at a considerable premium, which fluctuates almost daily. It is believed that there are in all about 4,000,000 dollars in the province of Wuhu, of which not more than 1,700,000 are in circulation, the remainder being hoarded by the peasantry.

There are several ways of classifying engines. They may be classified according to the style of cut-off; positive cut-off engines in which the steam is cut-off at the same point in each stroke of the piston, the admission of steam from the steam pipe to the steam chest being controlled by the governor; adjustable cut-off engines in which the point of cut-off can be adjusted by the engineer at his pleasure by means of a screw, hand-wheel or reverse lever as in the case of a locomotive; automatic cut-off engines in which the governor controls the valve gear so that the admission of steam direct to the cylinder is governed instead of to the steam chest as in the case of the positive cut-off.

U. S. PATENTS
ESPECIALLY PREPARED FOR
COMPRESSED AIR

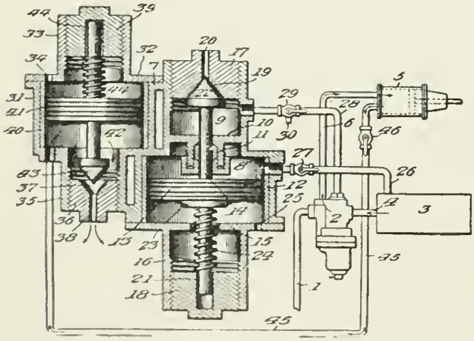
826,106. FLUID-PRESSURE-OPERATED TOOL. Charles H. Johnson, Chicago Heights, Ill., assignor, by mense assignments, to The Pittsburg Pneumatic Company, Canton, Ohio, a Corporation of New Jersey. Filed July 24, 1902. Serial No. 116,835.



Claim.—In a fluid-pressure-operated tool of the valveless type, the combination with a cylinder, of a reciprocating piston therein, said cylinder having motive-fluid supply and exhaust ports and passages for automatically terminating the stroke of the piston relatively to the cylinder upon the piston engaging an object.

826,249. APPARATUS FOR SEALING CANS, JARS, AND OTHER PACKAGES BY ATMOSPHERIC PRESSURE. Charles C. Hovey, Bainbridge, N. Y. Filed July 15, 1905. Serial No. 269,820.

826,322. AIR-BRAKE SYSTEM. David Felten, Parsons, Kans. Filed Nov. 25, 1905. Serial No. 289,139.



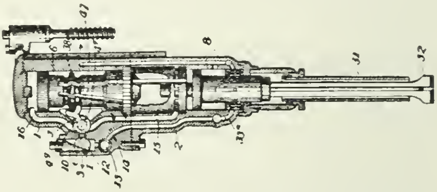
Claim.—In an air-brake system, a regulating-valve comprising a casing having two chambers separated by a partition, one of said chambers being provided with an outlet-port, a stem arranged in said chambers and sliding through said partition, a diaphragm arranged within the other chamber, means for subjecting the diaphragm to pressure on its side adjacent the partition, a spring acting on the opposite side of the diaphragm in opposition to such pressure, means for connecting the other chamber with the exhaust-port of the triple valve, and a valve carried by the stem and operating in said chamber to close the outlet-port therein.

826,330. AIR-CUSHIONING HEEL OR PAD FOR BOOTS OR SHOES. Edward N. Haag, West Philadelphia, Pa., assignor to Ferdinand H. Duckwitz, Philadelphia, Pa. Filed July 27, 1905. Serial No. 271,398.

826,353. COUPLING-RETAINING MEANS FOR METALLIC HOSE. Richard B. Painton, Williamsport, Pa., assignor of one-third to Jacob Hess Bailey, Muncy, Pa., and William Bailey, Jersey Shore, Pa. Filed Aug. 4, 1905. Serial No. 272,753.

826,397. PNEUMATIC COUPLER. Frederick L. Wood, Worcester, Mass., assignor to The Aeolian Company, New York, N. Y., a Corporation of Connecticut. Filed Oct. 28, 1905. Serial No. 284,864.

826,456. ENGINE FOR ROCK-DRILLING MACHINES. Cassius M. Walker, Pueblo, Colo., assignor to The Walker-Moore Rock Drill Manufacturing and Supply Company, Pueblo, Colo., a Corporation of Colorado. Original application filed Nov. 28, 1904. Serial No. 234,608. Divided and this application filed April 1, 1905. Serial No. 253,301.



Claim.—The combination with the cylinder of a rock-drilling machine and with its ports and tapering valve-socket closed at each end, of a tapering valve fitted to said socket, provided with two heads and an intervening web, the ports communicating with the space between the heads, a chamber beyond the larger head of the valve, a port in said head, a socket in the smaller head with separated shoulders below the same, and an arm with a head fitted to said socket and extending between the shoulders to have a limited motion independently of the valve for rocking the latter, substantially as set forth.

826,490. TIRE. James H. Swain, Pittsburg, Pa., assignor, by mense assignments, to H. M. & S. Armored Tire Company, Incorporated, Pittsburg, Pa., a Corporation of Pennsylvania. Filed July 25, 1905. Serial No. 271,184.

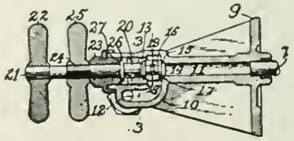
826,530. AUTOMATIC FLUID-PRESSURE REGULATOR. Rollo R. Bell, Chickasha, Okla., assignor of one-half to Wilson P. Bell, Ceres, N. Y. Filed Jan. 29, 1906. Serial No. 298,488.

826,555. VALVE FOR ICE-MACHINES. Frederick W. Felsberg, Dayton, Ky., assignor to The Triumph Ice Machine Company, Cincinnati, Ohio. Filed June 14, 1905. Serial No. 265,150.

826,612. TIRE. William B. Sawyer, Riverside, Cal., assignor of one-third to S. G. Armstrong, Riverside, Cal. Filed Dec. 5, 1905. Serial No. 290,461.

826,623. PNEUMATIC TIRE. James A. Swinehart, Akron, Ohio. Filed Oct. 25, 1905. Serial No. 284,272.

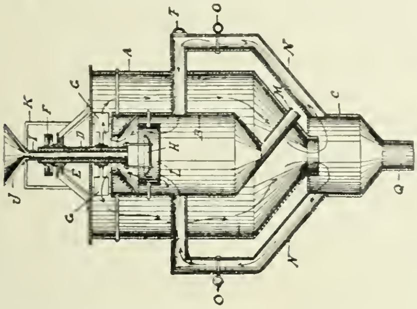
826,649. CUT-OUT VALVE FOR FLUID-COMPRESSORS. Niels A. Christensen, Milwaukee, Wis. Original application filed Sept. 9, 1899. Serial No. 729,957. Divided and this application Dec. 11, 1899. Serial No. 739,899.



Claim.—A cut-out valve for compressors comprising a valve-casing provided with a valve-chamber having an inlet from the compressor and also having an outlet, a valve in such chamber governing the communication between the inlet and outlet, a screw-threaded body arranged to screw upon the inner wall of the casing and upon which said valve is rotatably mounted, a longitudinally-movable stem coöperating with said body to rotate it, and a collar arranged on said stem to seat upon an inner wall of the casing.

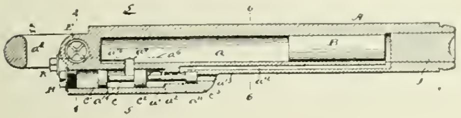
826,725. MACHINE FOR DELIVERING LIQUIDS. Alexander F. Humphrey, Allegheny, Henry McCrory, Wilkinsburg, and Frank D. Saupp, Jr., Pittsburg, Pa. Filed June 7, 1905. Serial No. 264,113.

826,772. AIR-SEPARATOR. George S. Emerick, Philadelphia, Pa. Filed Jan. 5, 1905. Renewed May 26, 1906. Serial No. 318,831.



Claim.—In combination, in an air-separator, an outer casing, an auxiliary chamber joined to and communicating with the outlet of said outer casing, an inner casing disposed within said outer casing, and a plurality of pipes forming a connection between said auxiliary chamber and said inner casing, substantially as and for the purposes described.

826,780. BRAKE-SETTING DEVICE. Ellsworth Godley, Springfield, Ill. Filed Feb. 16, 1906. Serial No. 301,476.



Claim.—In a pneumatic tool, a barrel, a valve-casing on the outer side thereof parallel therewith and bored out tubularly from the head end of the tool, a screw-plug for closing said casing accessible from the head end of the tool, an automatic piston-valve in said casing, three passage-ways from said casing to the main bore of the barrel, combined with a second casing formed transversely at the head of the barrel, an admission-valve in such second casing, a looped handle for the tool formed beyond the second casing, means conveniently accessible at said handle for operating the admission-valve, and a passage-way formed along the wall of the barrel between said two casings, substantially as described.

826,833. PNEUMATIC ACTION FOR MECHANICAL MUSICAL INSTRUMENTS. William F. Cooper, Norwalk, Ohio, assignor of one-half to The A. B. Chase Co., Norwalk, Ohio, a Corporation of Ohio. Filed June 10, 1905. Serial No. 264,674.

826,885. ELASTIC-FLUID TURBINE. Richard H. Rice, Swampscott, Mass., assignor to General Electric Company, a Corporation of New York. Filed Jan. 23, 1906. Serial No. 297,396.

826,927. ELASTIC-FLUID TURBINE. James W. Ferguson, Sandusky, Ohio. Filed May 9, 1906. Serial No. 315,972.

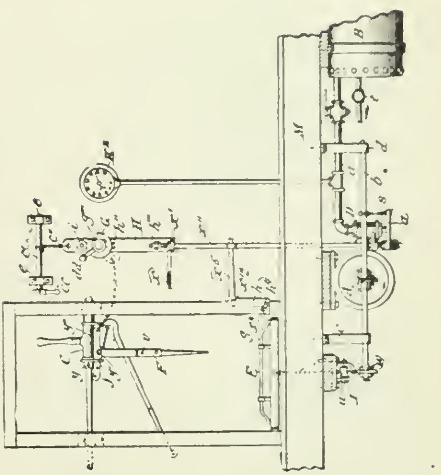
826,941. ELASTIC-FLUID TURBINE. Oscar Junggren, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Jan. 2, 1906. Serial No. 294,295.

826,979. VALVE-CONTROLLING MECHANISM. James Wilkinson, Providence, R. I., assignor to Wilkinson Turbine Company, a Corporation of Alabama. Filed July 3, 1905. Serial No. 268,203.

826,981. VALVE MECHANISM. James Wilkinson, Providence, R. I., assignor to Wilkinson Turbine Company, a Corporation of Alabama. Filed Sept. 22, 1905. Serial No. 270,810.

827,021. AIR AND VACUUM MOTOR. George W. Johnson, St. Joseph, Mo. Filed Jan. 23, 1904. Serial No. 190,304.

827,056. MAIL RECEIVING AND DELIVERING MECHANISM FOR RAILWAYS. Franklin H. Burr, Atlantic, Iowa, assignor to Railway Mail Equipment Co., Beresford, S. D., a Corporation. Filed Dec. 16, 1905. Serial No. 292,055.

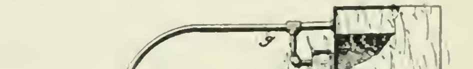


Claim.—In a delivery mechanism for railway-cars, the combination of a delivering-frame having a pivotal attachment to said cars, a compressed-air-operating cylinder having a piston pivotally attached to a swinging operating-lever, which is pivotally attached to said cars, and to said delivering-frame, and means for automatically swinging said lever whereby said delivering-frame is tilted and dumped, substantially as set forth.

827,060. AUTOMATIC SAFETY DEVICE FOR FLUID-COMPRESSORS. James W. Dawson, San Francisco, Cal., assignor of two-twelfth to George Beagley, San Francisco, Cal. Filed Dec. 31, 1904. Serial No. 239,254.

827,063. AIR-BRAKE APPARATUS. Albert H. Geltz, Alliance, and Lee L. Hosack, Youngstown, Ohio, assignors to C. B. McLean, Pittsburg, Pa. Filed April 1, 1905. Serial No. 253,342.

827,341. LIQUID-RAISING APPARATUS. George R. Young, Ridgewood, N. J., and Clifford Shaw, New York, N. Y., assignors to Bacon Air Lift Company, a Corporation of New Jersey. Original application filed Feb. 1, 1899. Serial No. 704,104. Divided and this application filed Jan. 18, 1902. Serial No. 90,292.



Claim. In combination, an air-compressing mechanism, an uptake for liquid, a downtake air-pipe conveying air from the compressor to the said uptake, a pressure-supporting separating-chamber into which the said uptake passes, a water-discharge passage leading from the separating-chamber and discharging against a static or dynamic resistance, an air-pipe leading from the said chamber to the said compressing mechanism, and means controlled by the static pressure of the liquid in said chamber for introducing additional air into the system.

WE beg to announce that during the early part of October we will be ready to make deliveries of Volume 10 of "Compressed Air" containing the issues from March, 1905, to March, 1906.

These volumes are substantially bound in black cloth with gold lettering and are invaluable records of the new uses and developments of compressed air during the last year.

We also have a limited supply of bound volumes covering a period of ten years. We shall be pleased to send a detailed list of such volumes together with prices.

COMPRESSED AIR

The Kobbe Company

90-92 W. Broadway, New York

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

NOVEMBER, 1906.

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COMPRESSED AIR CURVES AND TABLES.

WRITTEN FOR COMPRESSED AIR BY
L. L. WILLARD.

The formulae for calculating the horsepower required to compress a given volume of free air to a given pressure are:

for single stage H. P. =

$$\frac{144\ P_1\ V_1\ n}{33000\ \ (n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}-1\right]\ldots.(1)$$

for two stage H. P. =

$$\frac{144\times 2\ P_1\ V_1\ n}{33000\ (n-1)}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{2n}}-1\right](2).$$

for three stage H. P. =

$$\frac{144\times 3\ P_1\ V_1\ n}{33000\ (n-1)}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{3n}}\ 1\right]\ldots(3)$$

for four stage H. P. =

$$\frac{144\times 4\ P_1\ V_1\ n}{33000\ (n-1)}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{4n}}\ 1\right]\ldots.(4)$$

where P_1 = atmospheric pressure taken as 14.7 lbs. per □″.

P_2 = finial air pressure in lbs. per □″ absolute.

V_1 = volume of air at P_1 pressure in cubic feet per minute.

n = exponent of the compression curve, taken as 1.4 which is for adiabatic compression. This will vary from 1.2 to 1.4 depending on efficiency of cylinder jacket cooling.

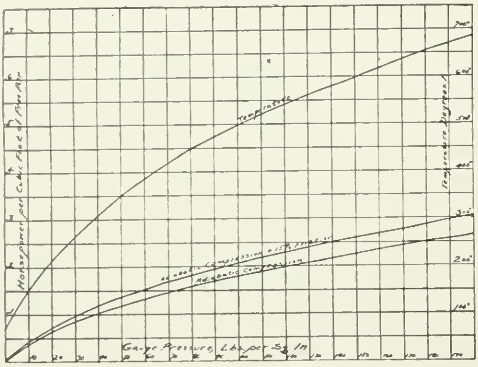
SINGLE STAGE

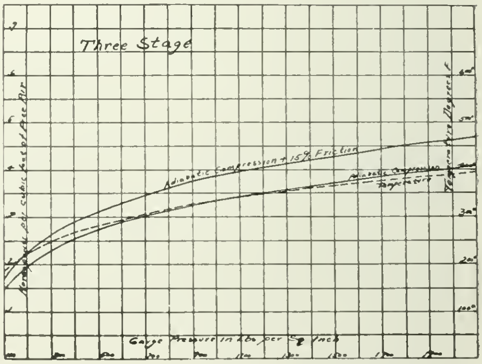
Gage Pressure	Absolute Pressure	No. of Atmospheres	H. P. per cubic ft. of Free Air	H. P. + 15% for Friction	M. E. P.	M. E. P. + 15%
5	19.7	1.34	.0197	.0227	4.50	5.17
10	24.7	1.68	.0362	.0416	8.30	9.55
15	29.7	2.02	.0504	.0580	11.51	13.25
20	34.7	2.36	.0628	.0722	14.40	16.55
25	39.7	2.70	.0742	.0853	17.00	19.55
30	44.7	3.04	.0845	.0972	19.40	22.30
35	49.7	3.38	.0944	.1085	21.65	24.90
40	54.7	3.72	.1030	.1185	23.60	27.20
45	59.7	4.06	.1112	.1288	25.50	29.35
50	64.7	4.40	.1195	.1375	27.50	31.50
55	69.7	4.74	.1268	.1458	29.10	33.42
60	74.7	5.08	.1339	.1540	30.75	35.30
65	79.7	5.42	.1408	.1620	32.30	37.15
70	84.7	5.76	.1472	.169	33.80	38.90
75	89.7	6.10	.1532	.176	35.18	40.40
80	94.7	6.44	.1590	.183	36.55	42.00
85	99.7	6.78	.1650	.190	37.90	43.60
90	104.7	7.12	.1705	.196	39.10	44.92
95	109.7	7.46	.1758	.202	40.35	46.35
100	114.7	7.80	.1812	.208	41.65	47.85
105	119.7	8.14	.1841	.212	42.30	48.60
110	124.7	8.18	.1908	.219	43.75	50.35
115	129.7	8.82	.1965	.226	45.16	51.90
120	134.7	9.16	.2008	.231	46.00	52.88
125	139.7	9.50	.2045	.235	47.05	54.10
130	144.7	9.84	.2085	.240	47.80	55.15
135	149.7	10.18	.2135	.245	48.85	56.20
140	154.7	10.52	.2176	.219	49.90	57.35
145	159.7	10.86	.2220	.255	51.00	58.60
150	164.7	11.20	.2255	.259	51.70	59.50
155	169.7	11.54	.2300	.264	52.80	60.75
160	174.7	11.88	.2321	.267	53.40	61.45
165	179.7	12.22	.2361	.271	54.20	62.45
170	184.7	12.56	.2408	.277	55.25	64.50
175	189.7	12.90	.2465	.284	56.50	65.00
180	194.7	13.24	.2480	.286	57.00	65.65
185	199.7	13.58	.2516	.290	57.50	66.20
190	204.7	13.92	.2550	.293	58.25	67.00
195	209.7	14.26	.2565	.296	59.00	67.80
200	214.7	14.60	.2600	.299	59.75	68.75

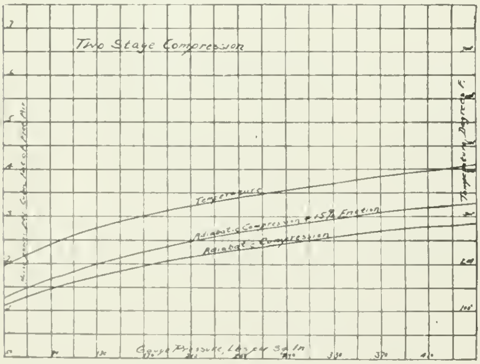
—*L. L. Willard*

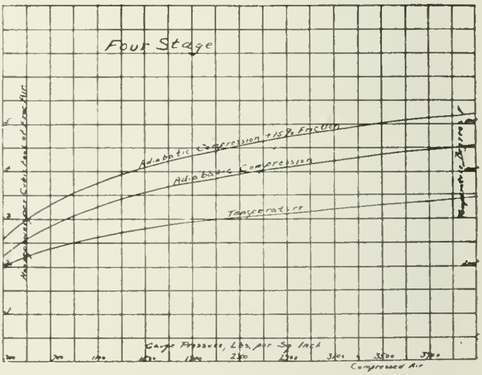
The cylinders should be so proportioned that equal work will be done in each.

For frequent use this formulae is inconvenient, requiring considerable time for its solution. For giving practically the same results the author has plotted the curves from values found by above formulae which will be found useful to any one calculating the power and size of air compressors. The tables are self-explanatory and the values are actual results. While the curves cannot be quite so accurate, they show very clearly the effects of compounding the cylinders and the saving in power and decreased temperature resulting thereby.









The values at the bottom of the diagrams represent the air pressure in pounds per square inch to which the air is to be compressed. The values at the extreme left are the horse-powers required to compress the air, both theoretically and with allowance for friction of 15 per cent.

If the compressor is to be located at a high altitude, less power will be required, and P_1 in the formula becomes less than 14.7, which will give a flatter curve. The horse-power varies directly as the weight of the air.

By taking the first values in the horse-power formulae and dividing, 144 ÷ 33,000, we obtain a constant .436, which if divided into the horse-power given will be the mean effective pressure developed in compressing the air.

The formula for calculating the temperature of the discharged air is

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

where T_2 = final temperature in Fahrenheit degrees.
T_1 = temperature of intake air in Fahrenheit degrees.
P_2 = final air pressure.
P_1 = atmospheric or intake pressure.
n = exponent of compression curve curve and taken as 1.4.

The pressures and temperatures are absolute and must be subtracted or added, as the case may be, to 14.7 pounds and 460.7°. In the curves and tables, T_1 is assumed as 70° and that the air is cooled to 70° between each stage of compression. As the cylinders should be proportioned to do the same work in each, the temperature resulting at the end of compression in each should be the same.

The temperature in degrees Fahrenheit will be found inside the margin on the left side of the diagrams.

TWO STAGE

Gage Pressure	Absolute Pressure	No. of Atmospheres	H. P per cubic ft. of Free Air	H P. + 15 % for Friction	M. E P.	M E. P. + 15%
50	64.7	4.40	.1063	.1225	24.30	27.90
60	74.7	5.08	.1184	.1260	27.20	31.30
70	84.7	5.76	.1286	.1478	29.50	33.90
80	94.7	6.44	.1372	.1580	31.45	35 20
90	104.7	7.12	.1462	.1685	33.55	38.50
100	114.7	7.80	.1542	.1770	35.40	40.70
110	124.7	8.48	.1615	.1855	37.03	42.60
120	134 7	9.16	.1681	.1935	38.80	44.60
130	144.7	9.84	.1740	.2010	39.90	45.70
140	154.7	10.52	.1810	.2080	41.52	47.75
150	164.7	11.20	.1865	.2145	42.75	49.20
160	174.7	11.88	.1912	2200	43.80	50.50
170	184.7	12.56	.1968	.2260	45.10	51.85
180	194.7	13 24	.2015	.2310	46.17	53.10
190	204.7	13.92	.2068	.2380	47.28	54.35
200	214.7	14.60	.2110	.2425	48.30	55.65
210	224.7	15.28	.2155	.2470	49.35	56.70
220	234.7	15.96	.2196	.2525	50.30	57.70
230	244.7	16 64	.2240	.2570	51.30	59.10
240	254.7	17.32	.2280	.2620	52.25	60 10
250	264.7	18.00	.2315	.2660	53.10	61.15
260	274.7	18.68	.2350	.2700	53.85	62.05
270	284.7	19.36	.2385	.2740	54.60	62.90
280	294.7	20.04	.2420	.2780	55.50	63.85
290	304.7	20.72	.2455	.2820	56.20	64.75
300	314.7	21.40	.2490	.2860	57.10	65.70
310	324 7	22.08	.2520	.2900	57.80	66.50
320	334.7	22.76	.2550	.2940	58.50	67.40
330	344.7	23.44	.2580	.2975	59.20	68.20
340	354.7	24.12	.2610	.3010	59.90	68.95
350	364.7	24.80	.2640	.3040	60.60	69.85
360	374 7	25.48	.2670	.3070	61.30	70.50
370	384.7	26.16	.2695	.3100	61.90	71.30
380	394.7	26.84	.2720	.3130	62.40	71.75
390	404.7	27.52	.2745	.3160	62.90	72.30
400	414.7	28.20	.2770	.3190	63.60	73.20
410	424.7	28.88	.2795	.3215	64.10	73.90
420	434.7	29.56	.2820	.3245	64.70	74.50
430	444.7	30.24	.2845	.3270	65.30	75.20
440	454.7	30.92	.2870	.3295	65 80	75.75
450	464.7	31.60	.2895	.3320	66.30	76.30

L. L. Willard

THREE STAGE

Gage Pressure	Absolute Pressure	No. of Atmospheres	H. P per cubic ft. of Free Air	H. P + 15% for Friction	M. E. P.	M E. P. + 15%
100	114.7	7.8	.1450	.1670	33.30	38.30
150	164.7	11.2	.1752	.2018	40 30	46 50
200	214.7	14.6	1965	.2260	45.20	52.00
250	264.7	18.0	.2140	.2460	49 20	56.60
300	314.7	21.4	.2295	.2640	52.70	60.70
350	364.7	24.8	.2418	.2775	55.45	63.80
400	414.7	28 2	.2535	.2915	58.25	66.90
450	464 7	31.6	.2630	.3016	60.40	69.40
500	514.7	35.0	.2730	.3140	62.30	71.70
550	564 7	38.4	.2830	.3255	65.00	74.75
600	614.7	41.8	.2910	.3345	66.85	76.90
650	664.7	45.2	.2960	.3405	67.90	78 15
700	714.7	48.6	.3025	.3480	69.40	79.85
750	764.7	52.0	.3090	.3550	70.75	81.40
800	814.7	55.4	.3150	.3620	72.45	83.25
850	864.7	58.8	.3210	.3690	73.75	84.90
900	914 7	62.2	.3260	.3750	74.80	86.00
950	964 7	65.6	.3315	.3814	76.10	87.50
1000	1014.7	69.0	.3360	.3826	77.20	88.80
1050	1064.7	72.4	.3400	.3910	78.10	90.10
1100	1114.7	75.8	.3445	.3965	79.10	91.10
1150	1164.7	79.2	.3490	.4015	80.15	92.20
1200	1214.7	82.6	.3525	.4052	81.00	93 15
1250	1264.7	86.0	.3570	.4115	82.00	94.30
1300	1314.7	89.4	.3615	.4160	82.90	95.30
1350	1364.7	92.8	.3660	.4215	84.00	96.60
1400	1414.7	96.2	.3685	.4235	84.60	97.30
1450	1464.7	99.6	.3710	.4265	85 30	98.20
1500	1514.7	103.0	.3740	.4300	85 80	98.80
1550	1564.7	106.4	.3780	.4345	86.80	99.85
1600	1614.7	109.8	.3820	.4385	87.60	100.8
1650	1664.7	113.2	.3850	.4430	88.40	101.8
1700	1714.7	116.6	.3880	.4460	89 10	102.5
1750	1764.7	120.0	.3915	.4500	89.75	103.2
1800	1814.7	123.4	.3940	.4530	90.50	104.0
1850	1864.7	126.8	.3965	.4560	91.15	104.8
1900	1914 7	130.2	.3090	.4600	91.80	105.7
1950	1964.7	133.6	.4020	.4625	92.25	106.2
2000	2014.7	137 0	.4050	.4655	93.00	106.9
2050	2064.7	140.4	.4075	.4680	93.50	107.5
2100	2114.7	143.8	.4100	.4715	94.10	108.2

L. L. Willard

AUTOMATIC APPLIANCE FOR STOPPING AND RE-STARTING MINE CARS

In a paper read recently before the North of England Institute of Mining and Mechanical Engineers Mr. W. Galloway describes an automatic appliance for stopping and re-starting mine cars. This appliance has been installed at a colliery in South Wales, and successfully operated for more than a year, the weighing on the surface, and the loading and unloading of the cages at the top and bottom of the shaft being automatically effected without a hitch during this period. At Garth the appliance is worked by means of compressed air, but steam can be used and the details varied in many ways. As applied to weighing, the operation is as follows:

The axles of the full car, running at any velocity less than that required to overturn it, successively depress and pass over a pair of catches, which immediately rise up behind them. No sooner is the hinder axle clear of these, than the front axle, coming in contact with and pressing against another pair with the full force due to the momentum of the car, pushes the frame of the appliance and its connections, including the piston within a compressed air cylinder, to a greater or less distance in the same direction from a few inches to a foot, according to the greater or less velocity at which the car has been moving. But the pressure of the air within the cylinder, now acting like a spring, arrests the forward motion of the car and then draws it back until it stands directly over the center of the weighing platform. The operation of weighing having been completed, the weigher places his foot on the foot-plate, and thereby opens a valve by which the air-pressure is withdrawn from the right-hand side of the piston, and the latter, together with the frame, is pushed toward the right-hand side and the first pair of catches, pressing against the hinder axle of any car that happens to be in front of them, drive it forward at a greater or less velocity, according to the size or diameter of the cylinder and the higher or lower pressure of the air acting on the piston. When the frame has nearly reached the end of its intended stroke, a spring fixed to the weighing platform arrests the forward movement of the rod: the second pair of catches are thereby depressed, and the car continuing to run forward after the frame has come to a standstill, passes over them, and proceeds toward its destination. As soon as the hinder axle of the car is clear of the catches, the weigher removes his foot from the foot-plate, the valve closes automatically, the pressure of the air on the right-hand side of the piston is restored and the frame is drawn back to its original position, ready to receive another car. The rapidity with which the frame is drawn back depends on the area of the opening of a valve. The frame is covered with a sheet of iron to prevent coal or rubbish from falling into its interior, and the only openings in it are those through which the catches project. The points to be specially noted are that the moving cars are arrested gently, held in the desired position, and again discharged with the required velocity without muscular effort on the part of an attendant, and that, thereby, a substantial saving in both time and labor is effected. The average rate at which cars, each carrying 1 ton, can be stopped, steadied, weighed, and disposed of by this apparatus in the manner described is six per minute, or, more accurately, one car per 9.58 seconds. The time occupied in pushing a full or empty car of the same capacity into the cage, and thereby discharging the empty or full car in front of it, is about 3 seconds.

FOUR STAGE

Gage Pressure	Absolute Pressure	No. of Atmospheres	H. P. per cubic ft. of Free Air	H. P + 15% for Friction	M. E. P.	M. E. P. + 15%
300	314.7	21 40	.2195	.2520	50.25	57.80
400	414.7	28 20	.2430	.2795	55.80	64 20
500	514.7	35.00	.2600	.2990	59.70	68.70
600	614.7	41.80	.2750	.3185	63.15	72.60
700	714.7	48.60	.2885	.3320	66.25	76.25
800	814.7	55.40	.3000	.3450	68.80	79.25
900	914 7	62.20	.3100	.3565	71.20	82.00
1000	1014.7	69.00	.3195	.3675	73.35	84.50
1100	1114.7	75.80	.3285	.3780	75.50	86.80
1200	1214.7	82.60	.3350	.3855	77 00	88.50
1300	1314.7	89.40	.3415	.3925	78 40	90.20
1400	1414.7	96.20	.3485	.3985	80.10	92.15
1500	1514.7	103.0	.3560	.4080	81.75	94.00
1600	1614.7	109.8	3610	.4150	82.85	95.35
1700	1714.7	116.6	.3660	.4215	84.10	96.75
1800	1814.7	123 4	.3710	.4270	85.20	98.10
1900	1914.7	130.2	.3750	.4320	86.15	99.10
2000	2014.7	137.0	.3800	.4375	87.30	100.4
2100	2114.7	143 8	.3840	.4420	88.25	101.5
2200	2214.7	150.6	.3880	.4470	89.15	102.5
2300	2314.7	157.4	.3930	.4520	90.30	103 6
2400	2414.7	164.2	.3970	.4570	91.20	104.8
2500	2514.7	171.0	.4010	.4620	92 10	105.0
2600	2614.7	177.8	.4050	.4660	93.00	106.9
2700	2714.7	184.6	.4085	.4700	93.85	107.9
2800	2814.7	191.4	.4120	.4740	94.60	108.8
2900	2914.7	198.2	.4150	.4775	93.30	109.8
3000	3014.7	205.2	.4180	4810	86.10	110.7
3100	3114.7	211.8	.4215	.4845	96.60	111.4
3200	3214.7	218.6	.4250	.4880	97.40	111.9
3300	3314.7	225.4	.4285	.4910	98.30	113.0
3400	3400.7	232.4	.4315	.4950	99.20	114.0
3500	3514.7	239.0	.4340	.4990	99.80	114.9
3600	3614.7	245.8	.4355	.5015	100 0	115.0
3700	3714.7	252.6	.4385	.5045	100.8	115.8
3800	3814.7	259.4	.4410	.5070	101.2	116.3
3900	3914.7	266.2	.4430	.5100	101 8	117.0
4000	4014.7	273.0	.4450	.5120	102.3	117.5
4100	4114.7	279.8	.4480	.5150	103.0	118.3
4200	4214.7	286 6	.4510	.5180	103.6	118.9
4300	4314.7	293.4	.4525	.5210	104.0	119.5

L. L. Willard

A LONDON FIRE WAGON OF NOVEL DESIGN

Has a Sliding Fire Escape and Compressed Air Plant and a Speed of 31 Miles per Hour

One of the most recent acquisitions of the London County Council Fire Brigade is a 50 horse-power gasoline vehicle, of novel design and extreme usefulness. It is not a fire engine, but a first-aid appliance, which can do much toward the saving of life and property before a fire has fairly got hold of the premises.

This machine carries a "sliding carriage" fire escape, capable of reaching to the height of 55 feet when fully extended, and it has, in addition to the regulation boxes of tools and hose, a compressed air plant for extinguishing small fires.

This latter is capable of throwing a jet of water under a pressure of 150 pounds per square inch. It is not a chemical machine, but simply consists of a cylindrical water drum of 60 gallons capacity, which can be coupled up to a steel cylinder containing air compressed to about 2,000 pounds per square inch. There is a compressed air cylinder on each side of the water drum, each cylinder being approximately capable of discharging the drum twice, and the drum can, of course, be replenished very quickly from the nearest hydrant. The fire-escape itself is mounted so that it can be very rapidly unshipped, and even the operation of replacing it on the chassis only occupies about thirty seconds.

Ordinary semi-elliptic springs have been used for the suspension of the chassis, but shackles have been abandoned in favor of sliding guide-blocks for attaching the ends of the rear springs to the frame. When fully loaded, and with the men on board, the total weight is about 4 tons 15 cwt. It has a wheel base of 11 feet 6 inches, and measures over all 21 feet.

In a trial run recently in hilly Kent, over a distance of about 50 miles, the results were highly satisfactory, a speed of 31 miles per hour being maintained when necessary on the up-grade.

NOTES ON GREAT TUNNELS.*

By Lewis M. Haupt.
Prof. of Civil Engineering, Franklin Institute.

Tunnels, like bridges, are engineering devices for overcoming physical obstacles to traffic.

Although of ancient origin their recent great development is the outcome of the demands of modern civilization resulting from the increase in population and commerce.

The advent of railroads in 1827 gave an impetus to the building of tunnels to save time, distance and grade in the interchange of traffic. These "horizontal wells," as they were called, were excavated by hand labor, as they were comparatively short, but with the increase of tonnage and demands for greater economy in cost and time, more pretentious enterprises were undertaken, requiring the use of machinery and power for their completion. Thus the ingenuity of man was impressed to meet the difficult requirements of providing an unobstructed passageway through mountains or under rivers or city streets, in the least time and at a moderate cost.

It was not until tunneling machinery was reasonably perfected that long tunnels without shafts became at all practicable for transportation, although there were several constructed at enormous waste of time and labor, for drainage purposes.

The introduction of efficient drills may be said to date from the first American patent, issued to J. J. Couch, March 27, 1851, for a reciprocating, hollow piston-rod, working in a cylinder, operated by steam, but it had a constant feed and no provision for the rotation of the bit. He took out a second patent November 3, 1852, for some improvements, but in the meantime Stuart Guynn was busy on independent lines in applying the same idea in a practical machine,—also having a constant feed,—but it slumbered from 1851 until the contractor of the Hoosac Tunnel, in Massachusetts, Herman Haupt,* embodied with this hollow piston-rod an automatic feed and rotating device which produced a simple, light and effective drill capable of piercing granite at a rate of one inch per minute and weighing only about 125 pounds. In ordinary shale the speed was doubled. It was estimated that with this tool a progress of twelve feet per twenty-four hours could be made at a cost of $16.33 per lineal foot of single track (15x18), or at about half the price of hand work, and with four times the speed.

To prevent the loss of time in clearing the heading from the debris and gases incidental to blasting—as well as to facilitate the drilling of the holes—a system was devised by the contractor whereby the drills were mounted in series of three or four on columns, which served both as supports and feed pipes for power (steam or compressed air). Thus mounted the drills had a large range in altitude or azimuth. The jacks for clamping the staunchions in position and the ball and socket joint at the bottom of frames enabled the bits to be readily changed without removing the gang. The plant also included a low counterpoised derrick and truck, enabling the gangs of drills to be rolled to the rear of the heading, which was driven at the bottom. Prepared cartridges were placed in the holes, and held by a plug, wired in series, and discharged by a hand battery, simultaneously. A vacuum fan and conduit laid on the floor soon relieved the heading of foul gases, and the drills were rolled forward, set up, coupled and started without awaiting removal of debris. To protect men and machinery a section of heavy timbers laid on the floor was hoisted by a bell-crank lever to an upright position to serve as a screen during blasting. These several features are clearly shown in Figs 1 to 3, which also illustrate the auxiliary steam plant with tender, when that motor is found to be more expedient.

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*A paper read before the Franklin Institute, revised for publication.

* Died December 14, 1905.

Modification of this pioneer rock drill were made by Burleigh, DeVolson Wood, and others, to adapt them to the ever varying requirements of the service, and have led to the extensive manufacturing plants of the Ingorsoll-Rand, and other companies for supplying complete outfits of tunneling and mining machinery now in common use for all classes of excavations in hard materials.

The contract price for this tunnel was $2,000,000, while the cost was $50 per lineal foot, or for the full length nearly $1,300.000. It was the purpose of the contractor not to use a shaft but to drive from the ends on a rising gradient and ultimately, when the traffic increased sufficiently, to open a parallel tunnel by means of galleries from the first, at frequent intervals, thus greatly reducing the cost, improving the ventilation and avoiding lining. The State, however, saw great political possibilities in this enterprise, and by a change of administration, during the civil war, its control was assumed by the Commonwealth, the dimensions were changed to double track, a large dam built for power, and other radical departures made, which swelled the cost to about $10,000,000, or five times the amount of the original contract. A shaft was sunk 1,028 feet in depth, which was of little use in expediting the work and was of doubtful utility. This Hoosac Tunnel of five miles in length, the longest in the United States at the time, was simultaneous with that under Mt. Cenis, where a compressed air plant, operated by water-power, was installed by Mr. Sommelier, the experience from which was a factor in the designing of the plans for the Hoosac, and this in turn, for works of the present day. The close relations of the several long railroad tunnels will become more apparent by a brief chronological statement of their statistics and time of construction.

1. HOOSAC, MASS.

Work was commenced in 1854 and prosecuted by private contractors until the State took possession, September 4, 1862. It was enlarged, and completed July 1, 1876, when it was officially accepted. The total cost of the railroad and tunnel, forty-four miles, was $17,322,019, of which $3,287,835 was interest. The progress was greatly accelerated by the introduction of power drills, 1867, and of nitroglycerine, in 1870, which was manufactured by Geo. W. Mowbray, in the vicinity of North Adams. This gives an average progress of 5.5 feet per diem.

2. MT. CENIS* THE ALPS.

The project was first broached by Guisseppe Medail, a Swiss peasant, in 1838, and subsequently, in 1852, M. Colladou suggested driving it by the use of compresed air drills, operated by water-power, but it was not until 1857, after a report by experts, that the Piedmontese Parliament granted a charter and agreed to pay half the estimated cost, which was $7,760,000, but it ultimately paid for the entire work.

The first blast was fired August 18, 1857, and the headings met December 25, 1870. It was opened for use September 17, 1871. It was double-track, driven with bottom heading 9½x8½ feet. Average rate of progress, 8.00 feet per day. Total length, 42,158 feet, or 8.0 miles. Time, fourteen years in building. Cost, $14,498,352. Machine drills were introduced at the north end in 1861 and at the south end in 1863. The last year the rate was 14¾ feet per day.

3. SUTRO TUNNEL.

The third long tunnel built was designed to open up the famous Comstock lode, in Nevada, by providing better drainage and greater accessibility to the mines. The section was 12x16 feet and length 20,351 feet, or nearly four miles. Work was begun October 19, 1869, and completed about 1878. There were four shafts designed to be used in construction, three of which were over 1,000 feet deep, but two of

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* Drinker's Tunneling, p. 266.

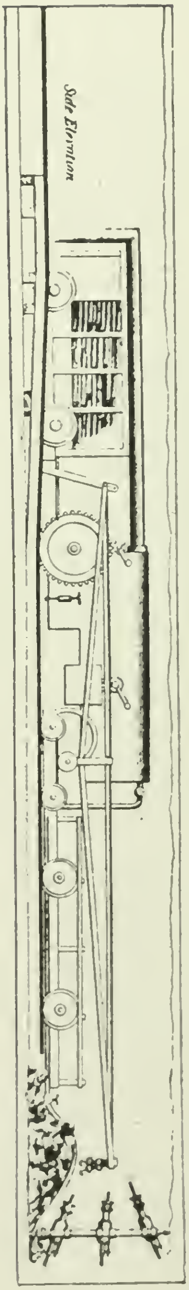

Fig. 1

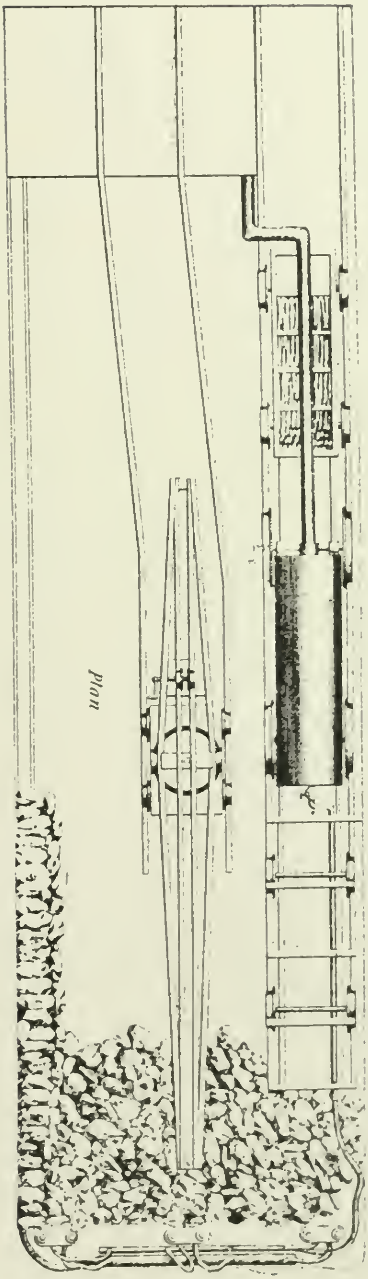

Fig. 2

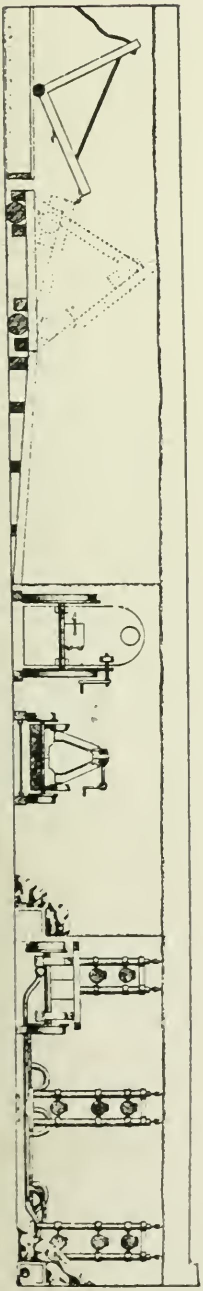

Fig. 3

them were abandoned before reaching grade because of the great influx of water. Progress per day (1875) in heading (10x8) was 10.24 feet.

4. ST. GOTHARD. ALPS (1872-81).

At the St. Gothard tunnel the Sommellier drills were used for a few years but were supplemented by those of McKean & Ferroux, making about 180 blows per minute. These McKean drills were modifications of the system designed for the Hoosac Tunnel and taken to Europe by Blanchard & McKean, agents for the contractor.

The contract for the St. Gothard was awarded to Mr. Louis Favre, August 7, 1872, at an estimated cost of $10,000.000, and was completed in eight years, with a premium of $1,000 per diem for every day saved or a similar penalty for each day lost. With the system of rapid firing and removal of debris great progress was made in each heading, and the work was opened in 1880—the first train passed through in 1881.

Its total length is nine and one-quarter miles; time, nine years, five months, and average daily progress, 14.6 feet, notwithstanding great difficulties from water and the caving of the lining. The early location of the approaches was placed high on the mountain slopes instead of the valley bottom, adding much to the expense, but this was afterward modified by the use of the spiral tunnel and loops.

THE ARLBERG TUNNEL. ALPS (1880-84).

Through the Austrian Tyrol a tunnel of 6.38 miles was driven between 1880 and 1884 at a much more rapid speed than any of its predecessors, at an estimated cost of $7,000,000. The time consumed was three years, nine months, and the average rate of progress 27.8 feet per diem. Work was conducted very systematically and construction trains were run by time schedules. The headings, which were 7.5 feet high and 9.2 feet wide, were placed at the bottom instead of the top of the tunnel. In cost, therefore, this work was but $1,000,000 per mile, $208 per foot, and in speed of execution three times as fast as Mt. Cenis.

THE SIMPLON. 1893-1905. 12¼ MILES LONG.

This tunnel, which connects Brig, in the Valley of the Rhone, with Iselle, on the Diveria, in Italy, is twelve and one-quarter miles in length. The contract was let in September, 1893. The plans contemplated the use of the system proposed for Hoosac of two single-track parallel tubes 16.5 feet wide, 55.7 feet apart, but connected by oblique galleries at frequent intervals. Only one of them was to be completed to full dimensions, while the second was to be used for subsidiary purposes to provide trackage for construction and ventilation, and to await the demands of traffic for its final enlargement. The cost is reported to be $15.500,000 to February 24, 1905, when the headings met, thus opening the shortest route by eighty miles between Paris and Milan, and connecting the Atlantic and the Mediterranean. The large amount of water and high temperature (reaching 118°F.) made this work one of unusual difficulty.

Actual work was begun in 1898, so that the average ratio has been nearly two miles a year, and it is a monument to the enterprise and energy of the countries which have contributed so liberally to the colossal work which at best will save but a few hours in transit between the Italian seaports and the British Isles. (For difficulties from hot springs see Scientific American of March 18 and 25, 1905).

SUBWAYS.

The feature of the above works is that they have generally been excavated from the ends, without intermediate shafts or slopes. Many more miles of continuous underground ways are now in existence, as in the numerous subways of Continental and American cities, but these have been built largely as open cuts or covered-ways, or with numerous shafts.

SUB-AQUEOUS.

Another important class of structures is the sub-aqueous passages connecting great centers of industries and taking the place of bridges. These involve greater difficulties and risks than are to be found in the previous classes, yet to avoid the transfers, delays and risks of ferries or the obstructions due to bridges, ice and fogs, they are found to be expedient, even at very great cost.

The latest and best practice in works of this kind is illustrated in the extensive system of tubes now completed and under construction by the Pennsylvania Railroad Company, under the direct supervision of Mr. Chas. M. Jacobs, Alfred Noble and others, in and across the rivers surrounding the Island of Manhattan, and connecting its western ramification directly with the greatest seaport of the continent, without break of bulk.

Whilst the tube-system as used underneath the North River at New York has required much ingenuity to adapt it to its purpose, the general idea was first applied in the pioneer work built under the Thames, at London, by M. I. Brunel, in 1825 to 1846. This structure is 1,200 feet long, with two passageways 14 feet wide by 16½ feet high, and is now used by the East London Railway.

The influx of mud and water were so great as to cause the invention of a shield to cover the whole face of the excavation, 38 feet wide and 22½ feet high. An attempt was made to introduce the Beach pneumatic system in New York about the year 1863, but it was untimely, and the traffic had not at that time reached such magnificent proportions as to justify the expense, and there was an aversion to being shot through a hole in the ground by the public. Electric motors were not then available. Again, in 1868-69, W. H. Barlow used a modified form of Brunel's shield in building the "Tower" subway under the Thames. This was circular in section, eight feet in outside diameter, and was lined with ribbed cast-iron plates. It was the prototype of the present generally adopted system. In 1889, a pair of tubes, each ten feet in diameter, was laid under the Thames by Mr. Greathead for the South London Railway by means of an improved shield telescoped over the outer end and pressed forward by jacks, as in the Tower subway.

The earliest sub-aqueous aqueduct tunnels in this country were those built at Chicago in 1864-67, two miles long, at a cost of $457,844, and subsequently extended four miles further for a fresh water supply. A second conduit eight feet in diameter and four miles long was added in 1887-1892, and also at Cleveland in 1869-74, when a conduit five feet in diameter and 6,606 feet long was built.

In 1888-1902, the Grand Trunk Railroad built a single-track circular tunnel, lined with cast-iron segments, by the use of shields, under the Detroit River, at Sarnia, through soft clay, sand and gravel 6,000 feet in length. To-day similar systems of sub-aqueous tunnels are being rapidly and successfully built under the North and East Rivers.

AQUEDUCTS.

Still another extensive group of tunnels is to be found in the aqueducts for supplying large communities with water. The most conspicuous example of this class is the Croton Aqueduct of thirty-three miles in length and about fourteen feet in diameter, crossing the Harlem River by means of an inverted syphon at a depth of 306 feet below the surface.

DRAINAGE TUNNELS.

Amongst the most interesting works of this class may be mentioned the ancient Desague de Huehuetoca, undertaken by Enrigue Martinez, a Dutch engineer, in 1607, for draining the basin of the City of Mexico. The tunnel was four miles long and the drain thirteen, but before the lining was completed a great flood caused it to cave in. As a reward for his effort the engineer was imprisoned for three years, and when released he was ordered to make an open cut, in which he spent the rest of his life. But the work was continued for 120 years, yet it was not made deep enough to relieve the basin to any great extent. In 1888, another tunnel was built six miles long and 150 square feet in section, supplemented by twenty-seven miles of large canals. this tunnel had twenty-four shafts, varying in depth from 75 to 325 feet and a discharging capacity of 450 cubic feet per second, and furnishes an excellent precedent for the problem now confronting the Isthmian Canal Commission engaged in the regulation of the floods of the Chagres River at Panama, where the success of the enterprise is made to depend upon the diversion of these torrential waters by means of tunnels from seven to ten miles in length through the Cordilleras. But in this case little is known of the geology or stratigraphy, and as to the possibility of any shafts being used.

Before closing these brief remarks it may be found expedient to glance at the attitude of the traffic problem in this city in 1888 as contrasted with present conditions. Then the necessity of additional facilities was urged by the official publications of this Institute, but was opposed by the vested interests handling the interurban traffic, because of the extreme cost of such works and terminals; of the "impossibility of satisfactorily operating the subway;" because "the subway car motor connected with the other lines of the road;" because "it would be unwholesome and unsatisfactory to the public;" because "it would forever preclude the growth of business on the lines of the company and prevent any extensions in the future to meet increased business," and lastly, because "the destruction of the railroad's terminal facilities in Philadelphia would entail a loss* impossible to estimate."

That these objections were untenable is evident from the fact that the "impossible" has vanished, and the underground and elevated roads have come to stay. Councils are now considering the necessity of abolishing all grade crossings and the steam routes are cheerfully acquiescing, while the city and railroad engineers are harmoniously working to relieve the surface from all rapid transit trains, as is best for the interests of all parties.

The Market Street subway contracts for sections 3 and 4, extending from Fifteenth Street west to the Schuylkill River, were let to E. E. Smith on April 1, 1903, and the work, which was begun April 6, has been vigorously prosecuted so that it is expected to be open for traffic this year (1905). It is designed for four tracks, two of which will carry express trains to connect with the elevated railroad building out Market Street from the east side of the Schuylkill to Delaware County. The four-track bridge across the river is now well under way. The local or outer tracks will make a loop at the eastern end, passing down Fifth to Walnut, thence to the River Delaware, to Arch, to Fifth and return to Market. The dimensions, in clear, are 48 feet 6 inches in width and 14 feet 6 inches in height from top of rails. The roof girders are supported by three rows of steel columns. The side walls are of reinforced concrete, and the work is being carried on without seriously interrupting local traffic.

Stations are placed at Fifteenth, Nineteenth and Twenty-fourth Streets.

Chicago has already constructed some twenty-eight miles of freight and passenger subways at a rate of twenty-one feet per day from each of the fourteen headings, the material being firm clay (See Scientific American, March 11, 1905) giving the unprecedented rate of progress of twelve miles in less than a year.

Boston has built a much-needed underground transit way, which is very popular and which has to some extent relieved the congestion of the surface, and the great work in New York goes rapidly on, but it is demonstrated that by the time one system is completed the increase of traffic has reached the limit of its capacity and another is demanded, so that to-day applications are being made for new charters under additional streets.

In view of the record of the past it is reasonable to look for the construction in the near future of the long-projected tunnels under the Straits of Dover to connect the British Isles with the Continent by a continuous line of rails, and the project of M. Lobel under Behrings Straits to join Alaska and Siberia, and thus furnish an all-rail overland connection between New York and St. Petersburg or Paris, or even with Cape Town in Africa, via the Cape to Cairo route.

These are some of the transformations which the engineers of the future may effect in the traffic routes of the world, through the instrumentality of great tunnels made practical by improved drilling machinery.

For further details see "Tunneling,'" by Henry S. Drinker. Johnson's Encyclopœdia article Tunnels, by Wm. R. Hatboro. Tunneling by Machinery, Herman Haupt, 1867.

THE PANAMA CANAL

Prof. William H. Burr, of Columbia University, recently addressed the American Association for the advancement of science on the work at Panama. Among other things, he said:

"The length of the Panama canal is about 45 miles between 40-ft. contours at low water at its terminal, but the length between shore lines will not be more than 42 miles.

"The topography of the isthmus at the Panama crossing is well adapted to the construction of this ship canal, the original summit of the divide on the line of the canal being but about 330 ft. above sea-level. This has now been reduced to about 170 ft. above mean sea-level by the French excavation at Culebra. About one-half of the length of the canal lies along low marshy ground on either side of the isthmus, making two natural sea-level sections, one about eighteen miles long on the northerly side of the isthmus, and the other about seven miles long on the southerly side; that on the northerly side running for the greater part of its length generally along the course of the Chagres river. This river has been one of the main features in the consideration of the canal work since the beginning of operations by the old Panama Canal Co. in 1881. It is not a large river, as it has not more than about 800 square miles of watershed above Bohio, where in its flow toward the sea it leaves the rising ground and enters what may be termed the coastal plain, through which it meanders along a sinuous course to the ocean. It has even changed its course in the past at various locations in this marshy ground.

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*See Rapid Transit in Cities, Jan., 1888, Journal of F. I. Feasibility of Underground Railroads, Dec., 1888, Journal of F. I.

"That portion of the canal route lying in the higher ground of the divide is but about 24 miles long, and but little more than three-quarters of a mile of it had an original surface elevation exceeding 200 ft. The surface material is largely clay of ordinary character, slippery and easily moved when wet, but holding well in place when protected from the entrance of water. Below this covering of clay lies material of irregular character, as the entire isthmus is of volcanic origin. In the continental divide, at a depth varying from 20 to 40 or 50 ft. below the surface, an indurated clay, classed for purposes of excavation as soft rock, is found. This material gives place irregularly to hard rock at greater depths. Much of the rock of the isthmus is soft, although there is hard basalt in a number of places and, in one locality on the Panama slope of the divide, columnar basalt is found.

"The work performed by the old and new Panama canal companies amounted in the aggregate to not far from eighty million cubic yards of all classes of excavation, of which possibly forty million cubic yards at most will be found available for the American construction of the canal, whether a lock plan or a sea-level plan be adopted. This work extends practically over the entire canal route, with the exception of the approach channels in the two terminal harbors, and it is nearly continuous. Over considerable stretches of the higher ground it is little more than shallow cuts through the softer surface materials, but at the great Culebra cut the material which has been excavated varies from the surface clay, readily removed by steam-shovels, to hard basaltic rock, requiring blasting by high explosives before it can be removed. All the material, even the indurated clay, below the softer covering, requires blasting before it can be excavated, although the softer portions need the action of black powder only.

"Except the deep cutting at Culebra, through the summit of the continental divide, the most marked work done by the old French company was the dredging through the low marshy lands from Colon to Bohio. There is at present a strip of partially completed canal about 14 miles long with a bottom width of 72 ft., which may be navigated by vessels drawing 12 to 14 ft., with the exception of a short distance near Colon. Indeed, so much excavation was completed in this portion of the canal, intersecting the Chagres at a number of places, that the waters of that river have abandoned the old bed and now flow through the partially completed canal prism."

PNEUMATIC TOOLS AS APPLIED TO SHIP CONSTRUCTION AND THEIR ADVANTAGES TO SHIPBUILDERS AND ENGINEERS*

BY CHARLES SCHOFIELD.

About three years ago the shipyard managers of the United States decided to ascertain whether pneumatic tools as applied to ship construction were a financial success or not, and what actual advantages accrued from their use. They appointed a committee, instructing them to make the necessary inquiries from the various shipbuilders of America, and report the result of their labors at the next meeting. The paper presented caused more discussion and diversity of opinion than any other topic during the whole session. The reports of the various shipbuilders as returned disclosed a most satisfactory state of affairs, and proved beyond a doubt that pneumatic tools as applied to ship construction were a known quantity and beyond the experimental stage. The information thus obtained was not only interesting but instructive to the members generally.

I will endeavor in my paper to explain the methods adopted in the American shipyards as to the application of pneumatic tools in ship construction, also the cost of same, and make a comparison with the British piece-work hand rates.

The first portable pneumatic tools introduced to shipbuilders were shipping hammers. A pneumatic chipping hammer consists of a working cylinder, having attached to it a grasping handle, and inclosing a reciprocating piston and a valve box containing a reciprocating valve. In the lower part of the handle the air-inlet passage is situated, and is controlled by a piston throttle valve arranged therein, adapted to be operated by a pivoted finger lever. The air, after passing the valve, enters the transverse passage, which communicates with an annular groove situated immediately adjacent to the valve box. This groove serves to distribute the air to the various inlet ports and passages in the valve box. The valve box itself is in the form of a hollow cylindrical block bored out to two different diameters to receive the valve corresponding in shape. The valve box is provided with the necessary ports and passages to admit live air to and exhaust from the opposite ends of the cylinder, and for controlling the valve itself in co-operation with the piston. The valve contains no ports or passages, but has two grooves, one cut in the portion of small diameter, and one in that of large diameter. It will be seen that the valve, being made of two diameters, has two pressure surfaces or areas, against the smaller of which air constantly acts to press the valve in one direction; and against the larger area, air under pressure is intermittently admitted through the ports and passages in the valve box and cylinder, those in the cylinder being so controlled by the piston as to move the valve in the opposite direction against the constant live-air pressure on the smaller area. The piston is a solid cylindrical bolt having a groove in its periphery near one end for the purpose of placing in communication with each other the live-air passage, shown in dotted lines leading from the source of supply to the piston chamber, and another passage leading from the piston chamber to the larger area of the valve. The outer end of the cylinder is partly closed by means of an internal ring and the working tools socket. When the working tool is inserted into the tool socket the closure of the end of the cylinder is thereby completed.

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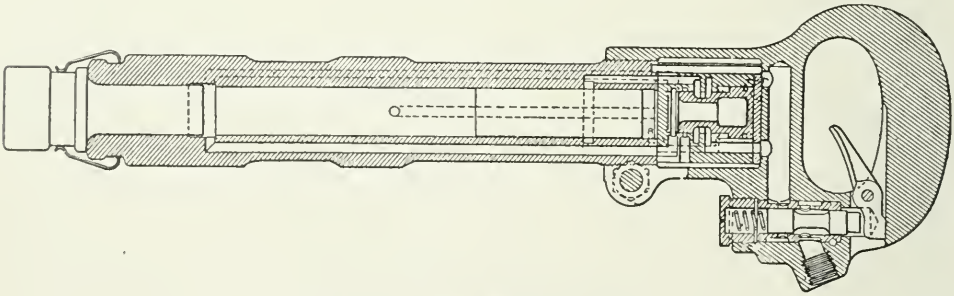
*Read before the North East Coast Institution of Shipbuilders Engineers, November 24, 1905.

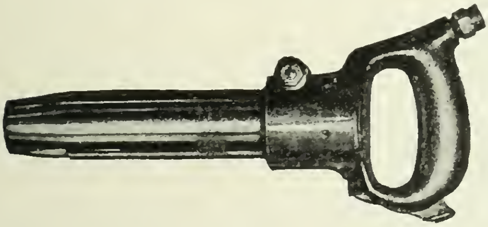
In the illustration the valve is in such position that the air is in contact directly with the piston so as to force it forward at high speed until it hits the tool end. When the portion of reduced diameter of the piston comes opposite to the end of the live-air passage, and puts this into communication with the passage leading back to the large area of the valve, the position of the valve is immediately reversed, whereby the live air passes round the groove in the portion of the valve of large diameter into the passage on the opposite side at the front of the piston, forcing the same in a backward direction. The piston on its return stroke cuts off the supply of air from the larger area of the valve, and the latter returns to its initial position, admitting air behind the piston for the next stroke.



SECTION OF PNEUMATIC RIVETER.

Is was with fear and trembling that we, the shipyard managers, attended the several demonstrations prepared for our edification by the various pneumatic tool companies, as, of course, we were expected to try the tools; and sometimes we thought the piston was taking air at the wrong end on account of the excessive vibration, but this was eventually minimized by the makers adding a little more weight to the hammers. After we had got accustomed to handling the tools and had overcome, to some extent, our prejudice, it became evident to us that the pneumatic chipping hammer had some merit; inasmuch as it could do work in close quarters much better and in less than half the time the same work could be done by hand.

It was, however, months before we could get the men using pneumatic tools to admit that there was sufficient benefit derived from their use to warrant a reduction from the hand piece-work rate, and it was only by playing our cards diplomatically that we got our first reduction of 40 per cent. on all chipping and cutting, because, at this time, the men experienced great difficulty in chipping a plate edge to a bevel, or when dressing a shell butt, on account of the hammers having round bushings to take the shank of the chisel, whereby the man operating the tool had to twist the chisel as best he could without any resistance from the hammer. But all the up-to-date hammers of to-day have hexagon bushings, and the chisels have hexagon shanks to suit, so that the operator can twist the chisel to any desired angle by twisting the hammer, while a calking iron with a round shank can be used in the same hammer without the bushing being changed. The current piece-work rate for pneumatic chipping, solid cutting and calking in the United States is about 50 per cent. less than the piece-work hand rates of Great Britain; that is, taking the day-work rates of both countries as a basis. Another feature of the pneumatic calking hammer is that it calks the toe of the gunwale, waterway, tank margin and bulkhead bounding bars without their having been either planed or chipped. This allows the builder to order the said angles the same size as he would if they were not to be calked.



PNEUMATIC CHIPPING HAMMER.

Pneumatic hammers are used extensively by engineers for dressing propeller blades, the palms of struts for vessels with twin screws, bed plates, cutting key ways, cleaning castings, etc., in fact, there is very little hand chipping done in the fitting shops of the American engine builders.

PNEUMATIC DRILLS.

When pneumatic drills were first introduced to shipbuilders they had to compete with electric drills of all sizes and weights; and during a four weeks' test at the works of William Cramp & Sons, of Philadelphia, the pneumatic drills proved their superiority. At the time of the test we were building three cruisers and two battleships, which had protective decks made up of two plates, each 1½ inches thick, connected by 1¼-inch rivets. It was on these plates we made the test, the average for the twenty-four days being as follows:

Air pressure on 12 days, being 90 pounds 248

AIR PRESSURE	Holes Drilled	
	Pneumatic	Electric
On 12 days, being 90 lbs.	248	100
On 9 days, being 84 lbs..........	232	100
On 3 days, being 76 lbs..........	208	100

The result was that we dispensed with twenty-six electric drills, and took 60 per cent. off the piece-work rate of drilling on this class of work; we also made a reduction of 60 per cent. on the price of holes drilled in the deck plating for deck planking, and took 50 per cent. off all other drilling on the ship, except odd work.

Pneumatic drills are now used for every conceivable purpose by American shipbuilders, among others, cutting out side-light holes, ventilator and coal port-holes in the deck, boring stern-post gudgeons, wood backing for armor-plate bolts, tube cutting, tube expanding, tapping for stay bolts, screwing in stay bolts, and by using a speed reducing gear attached to the drill it is possible to tap up to 4 inches diameter, and to operate this combined machine only one man and a boy are required. In fact, the pneumatic drill is an indispensable factor in connection with speedy and economical ship construction in its various branches.

PNEUMATIC RIVETING.

Probably the hardest manual labor in all the various operations in building a ship is that of riveting. Combined with this is a certain amount of technical skill acquired only by an apprenticeship at the trade. A first class riveter on inside work cannot properly drive shell rivets and *vice versa*, while the boiler riveter, however good he may be at his own work, is of little use on any part of the ship's hull. In addition to this, the rapidly increasing size of ships, with the corresponding necessity for heavier plating, doublings, etc., requires the use of larger and longer rivets, which cannot properly fill the hole when driven by hand, however skilful or willing the men may be.

For all these reasons combined, in the yard of the Cramp Company, of which I was the shipyard manager, some seven years ago a determined effort was begun and an extended series of experiments entered upon to develop pneumatic machinery capable of being operated by unskilled labor, by which all the rivets in the ship could be driven. This effort has been entirely successful, not only at Cramp's but at all the leading shipyards in the States.

I recently sent to the four leading shipbuilders in America a letter asking them to cable me the approximate percentage of the entire number of rivets in the shell of a ship which they were now driving with pneumatic tools.

I received the following cablegrams in reply:

"Eighty-five to ninety."—James Wallace, Managing Director for the American Shipbuilding Company.

"Thirty shell, eighty hull."—Orcutt, President of the Newport News Shipbuilding Company.

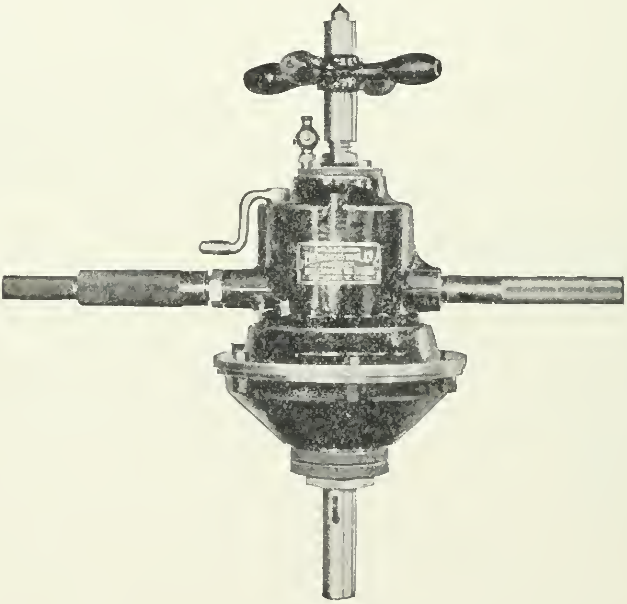
"One hundred."—Wilson, General Manager, Marine Department, The Maryland Steel Company, Sparrow's Point.

"Ninety-nine." Cramps.

The last cablegram was confirmed by letter.

We had in use at that time, a stationary riveter of the ordinary type, driving rivets in such portions of the ship as could be assembled and handled as a whole, namely, frames, water-tight doors, etc., such as are usual in ordinary merchant vessels. A very short experience with compression riveters showed that their great weight—reaching over 2,500 pounds for a six-foot gap—interfered too much with facility of handling to make them either useful or economical.

We then turned our attention to the pneumatic hammer, which delivers an almost continuous series of blows against the end of the chisel, calking tool, or rivet die. The hammer is light, powerful, short enough to go in between frame spacings, and small enough in diameter to get at rivets in corner angles. For rivets up to ¾-inch diameter it can be held in the hand, but for rivets of a larger diameter the hammer should be held in a device suitable to the location of the work on the vessel, for instance, shell device and deck device. It is, however, almost impossible to hold on to the rivet by hand unless a spring dolly bar is used instead of the heavy holding-on hammer used in hand riveting, the heavy holding-on hammer being fairly jarred off the head of the rivet by the rapidity of the blows from the



PNEUMATIC ROTARY DRILL.

pneumatic hammer, giving the holder-on no opportunity to bring his tool back into position between blows as in hand riveting.

PORTABLE PNEUMATIC YOKE RIVETER COMPLETE.

In connection with the above-mentioned pneumatic hammer there is used a simple pneumatic hold-on consisting only of a cylinder carrying a piston, behind which air is admitted, the rod extending through the front head and being cupped out to go over the head of the rivet.

Combining these two machines with a yoke, the hammer being mounted on one arm and the holder-on on the other, makes a self-contained machine in which the yoke can be made very light, as it has to resist only the pressure of the air against the end of the holder-on cylinder, and the reaction of the hammer blows. Various sizes of these yoke riveters are used for riveting the center keelsons, longitudinals, side keelsons, etc. They are also extensively used for riveting certain parts of turrets, gun-carriages, etc., where first-class riveting is absolutely necessary.

For driving rivets in frames and brackets, intercostals and beam knees, etc., we use a jam riveter and pneumatic-holder-on.

The above descriptions will, I trust, make sufficiently plain the methods for driving all rivets that can be reached on both sides by a yoke or jam riveter. There remain three classes of rivets in a ship, as follows: (1) Those through decks and tank tops, mostly countersunk, and all driven downward from above; (2) bulkhead rivets, nearly all with full heads; (3) those in the outside of the vessel and all countersunk. These three classes must be reached by riveters on one side and holders-on on the other, without any connection whatever between them. The first class are most easily driven, and for them the hammer is attached to a universal swivel head, mounted on a pipe or T-bar. The operator raises the hammer to bring the flat die on to the rivet, and the pipe or T-bar being secured at the center, holds the hammer in position while the rivet is being driven. A second man, with a pneumatic chipping hammer cuts off the surplus metal, and the riveting hammer being brought back on the rivet, a few seconds complete the operation. In this case the pneumatic holder-on is operated from below by a third man, being braced against the bottom of the ship or the next deck below.

For the second class, the hammer is simply held in the hands of the operator, said hammer having about a 4½-inch piston stroke, and as the die is cupped out to form the snap point, there is no tendency to slip off the point. The holding-on is done by a spring dolly bar, which I will explain later.

We now come to the third class, or shell rivets, which, in many respects, are the most important rivets in the ship, requiring the most careful workmanship and the best finish. Therefore it is a serious mistake for shipbuilders to attempt to drive shell rivets by pneumatic power until they have established pneumatic riveting on all inside work, because the men operating the tools should be accustomed to handling the hammers before being put on this important part of the work. It is evident at the start that the varying thickness of plates, frame flanges and liners, and especially the depths of countersink render it impracticable to so gauge the length of rivet used that there will always be just enough metal to properly fill the countersink and finish the point, and that, therefore, as in hand riveting, a longer rivet must be used. After the point is beaten down and the surplus metal crowded off to one side, this surplus must be chipped off, and the point be finished up, rounded slightly, and any seams between the rivet and the plate driven together and closed. To do this a certain amount of freedom of motion must be allowed in the hammer, so that its axis may be inclined at a slight angle in any direction with the axis of the rivet itself.

This result is attained by mounting a pneumatic hammer in a device having a universal movement attached to the end of a T-bar, instead of its being immovably fastened to it For bottom riveting there is a flat bar adapted so as to be mounted on the shell of a ship in any desired position. This bar carries an adjustable support, connected, by means of a swivel joint, with a holder in which is mounted an adjustable frame bar, pivotally supporting at one end a pneumatic hammer, and at the other an adjustable distance piece.

At one setting a space of 14 feet to 16 feet square can be reached with the above device, and when it is necessary to move the device to another position the change can be effected in about ten minutes. A spring dolly bar is used for holding-on, thus dispensing with the costly method of a wood backing, necessary when a pneumatic holder-on was used, as was the case a few years ago, and an ordinary pneumatic chipping hammer is used to cut off the surplus metal before finally finishing. It is evident that the freedom of movement of the hammer can be secured in other ways, such as a ball and socket joint of large radius, but we have found the above device more satisfactory and all that can be desired.

	Holes drilled.	
	Pneumatic.	Electric.
Air pressure on 12 days, being 90 pounds	248	100
" 9 " 84 "	232	100
" 3 " 76 "	208	100

Distribution.	No. of Rivets.	Diameter of Rivets. Inch.	Machine Rate. Each. Cents.	Hand Rate, Each. Cents.
Keel (flat)	6,217	1	2½	4½
Shell	21,628	⅞	1¾	3½
Shell margin (bilge single line)	1,122	⅞	3	4½
Longitudinals, open	24,632	¾	1¼	2¾
C. V. K. brackets	3,197	¾	1	3½
" "	......	..	1¼	3½
" "	......	..	1½	3½
Longitudinals under tank	664	¾	1¾	2¾
Longitudinals, bars	2,989	¾	1¼	2¾
Tank top stiffeners	1,129	¾	2½	3½
Tank top margin	4 033	¾	1½	2¾
Tank top rider	3,209	¾	1¼	2¾
Tank top lugs	1,520	¾	1¾	3½
Tank top	4,467	¾	1¼	2¾
C. V. K. cross vertical keelson	12 723	¾	1	3
Hold stringer	1,184	¾	1½	3
Floors	123	¾	1¼	3
Floors (odd)	5	¾	2	6
C. V. K. (odd)	38	¾	2	6
Bulkheads	1,318	¾	1¼	5
"	3,051	¾	1¼	3¼
"	231	⅝	1½	2½
Total	93,480			

TABLE I.

For riveting the side shell plating the same device is used, with one exception, and this is as follows: there is a holder provided with a T-shaped slot, the sides of which form a bearing for the T-shaped frame bar, while allowing said bar to be moved from one position to another in said slot; and a friction spring and set screw, respectively adapted to bear against the bottom of said frame bar when the latter is in position in said slot and to lock the frame bar in any desired position in said holder.

The spring dolly bar now used is made of a piece of 3-inch pipe about 12 inches long, having at one end an ordinary cast-steel handle, while at the other there is a bushing, through which a set screw holds the cup or snap. Inside the pipe there is a piece of round iron, about 6 inches long, backed up by a spiral spring.

The quality of the work done by all these machines, both inside and outside the shell, is first-class in every respect, and far superior to hand work, seeing that a rivet driven by a pneumatic hammer has to be about 12 per cent. longer than a rivet driven by hand, which goes to prove that the hole is better filled when the work is done by pneumatic tools, and such is the unanimous opinion of the inspectors who have been and are on duty in the American shipyards.

That this is natural appears from several considerations. The rivets are closed down more rapidly and at a much higher temperature, and, as it is always easy to bring the axis of the hammer in line with the axis of the rivet, and, in fact, natural for the men to do so, the rivet is plugged at once by the first blows of the hammer, thoroughly filling the hole throughout before the point begins to form. The tendency of hand riveters to save labor, to form the point without thorough plugging, leaving a rivet which, though looking all right and passing the tester, is liable to loosen afterwards in service from the constant jar and vibration of the hull, is, therefore, avoided. In many confined places, also, where only one man can strike, and the space for the swing of the hammer is confined to the frame spacing or less, hand rivets are very apt to be poorly driven, but it is evident that such considerations do not affect the machine, and that, if the pneumatic hammer can get to the rivet at all, it is as well put in as in the most open parts of the work.

As to the cost of pneumatic riveting, I submit the figures of Table 1, which are piece work rates current in the States, also figures comparing them with the British piece-work hand rates. In making this comparison, I must call your attention to the fact that both day-work and piece-work rates in America are about 35 per cent. higher than in Great Britain. This is due chiefly to the cost of living being higher. So that the piece-work prices for pneumatic riveting in Great Britain should be one-third less than the prices paid in America.

Table 1 was compiled from an actual test covering a period of three weeks at the Chicago plant of the American Shipbuilding Company.

Total cost of job by hand would have been	$2,986.87
Total cost of job by machine was	1,403.31
Saving of machine over hand work	$1,583.56
Average cost per rivet of hand work	3.19 cents
Average cost per rivet of machine work	1.50 "
Average saving per rivet of machine hand work	1.69 "

Average cost of machine riveting was 47 per cent. of hand cost.

If the above 93,480 rivets had been driven by pneumatic tools in a vessel building in a British shipyard at piece-work rates one-third less than are paid in America, the result would be as shown in Table 2.

The amount that should be added to machine cost to cover interest, maintenance of plant, and operation of compressor, is about 15 per cent. of the gross earnings of the tools.

It is only fair to mention that, at the time the above test took place, about seven years ago, pneumatic tools were not so perfect as they are to-day, and their application to ship construction has been very much simplified. For instance, when driving bulkheads and shell it was customary to use a pneumatic holder-on, which necessitated something to act as a backing for the tool, said backing having to be built up, which added considerably to the total cost of riveting, whereas now a spring dolly bar is used, which the holder-on holds in his hands; again, the shell device for holding the riveting hammer while driving the rivet has been very considerably improved, and can be removed from one position to another on the ship in less than one-fifth the time required to remove the old device.

In conclusion, I should like to say that, while visiting the various shipyards on the Clyde, one of the most prominent shipbuilders called my attention to the fact that since commencing to use pneumatic tools they have turned out 20 per cent. more tonnage, from the same building berths, than they did before. So there is not only a saving in the reduced price of work done by pneumatic tools, but also a great saving in time, which is a very important item to a shipbuilding company which is limited as to space and has not sufficient berths to accommodate all the vessels under order.

Thus it will be seen that, while pneumatic tools are still only in their infancy, there is no limit to the advantages that shipbuilders and engineers can gain by their use in connection with shipbuilding and engineering. In addition to the tools already mentioned, there are now on the market pneumatic hoists, rammers, molding machines, wood-deck calking machines, wood-deck planing machines, painting machines, and large hammers for blacksmith work.

THE SCRANTON TUNNEL OF THE LACKAWANNA AND WYOMING VALLEY RAILROAD

During the years 1901, 1902 and 1903 a double-track, high-speed electric railway was constructed for this company on a private right of way in the heart of the northern anthracite coal field, with termini at Wilkes-Barre on the south, and Scranton on the north, a distance of about 20 miles.

The entrance to Scranton was over a hill on the southern side of the city and, during 1904 and 1905, a tunnel was constructed through this hill. In a paper recently presented before the American Society of Engineers, Messrs. Geo. B. Francis and W. F. Dennis, members Am. Soc. C. E., mention the following interesting facts relative to the use of compressed air in connection with the work:

The company's plans required two shafts, and the simultaneous excavation both ways from each shaft, and at the ends, thus making six points of simultaneous attack.

It was calculated that from 24 to 28 drills would be necessary, and the requisite air supply was approximated at, roughly, 100 ft. per min. for each drill, at 100 lbs. per sq. in., and the boiler capacity at 20-H. P. to each drill. There was actually installed one 80-H. P. and three 150-H. P. boilers, all being return-tubular with brick arch, cast-iron fronts and iron stacks, making a total boiler capacity of 530 H. P.

		British Pneumatic.					British Hand.				
Distribution.	No. of Rivets.	Price per 100		Total Cost.			Piece-work.		Total Cost.		
		s.	d.	£	s.	d.	s.	d.	£	s.	d.
Keel (flat)	6,217	7	0	21	15	2	11	10	36	15	8
Shell	21,628	5	0	54	1	5	8	8	93	14	5
Tank margin	1,122	8	4	4	13	6	10	0	5	12	2
Longitudinals, open	24,632	3	6	43	2	1	8	6	104	13	9
C. V. K. brackets	3,197	3	6	5	11	10	8	6	13	11	9
Longitudinals under tank.	644	5	0	1	13	2	9	6	3	3	1
Longitudinals, bars	2.989	3	6	5	4	7	9	6	14	3	11
Tank top stiffeners	1,129	7	0	3	19	0	10	0	5	12	11
Tank top margin	4.033	4	2	8	8	0	10	6	21	3	6
Tank top lugs	1,520	5	0	3	16	0	10	0	7	12	0
Tank top rider	3.209	3	6	5	12	4	10	6	16	16	11
Tank top	4.467	3	6	7	16	4	10	6	23	8	0
C. V. K. vertical keelson..	12.723	2	10	18	0	6	8	6	54	1	5
Hold stringer	1,184	4	2	2	9	4	8	6	5	0	8
Floors	123	3	6	0	4	4	8	6	0	10	5
Floors (odd)	5	5	9	0	0	4	11	6	0	0	7
C. V. K. (odd)	38	5	9	0	2	2	11	6	0	4	4
Bulkheads	3.051	4	2	6	7	1	7	0	10	13	7
				£192	17	2			£416	19	1
									192	17	2
Amount saved by machine over hand (British rates)									£224	1	11

TARLE 2.

The selection of the compressors was governed by the plant on hand, and comprised one Rand straight-line, 16x24-in., of about 600 ft. capacity, two Rand straight-line, 20x30-in., each of about 1,000 ft. capacity. At times all these compressors were run at about 20% more than their normal speed of 110 rev. per min., and, roughly, their combined capacity was increased to 3,000 ft. of air per minute when working at their maximum. The three 150-H. P. boilers provided an ample supply of steam, without the assistance of the 80-H. P. boiler, and the results indicate that the preliminary allowance was high, and that about 15-H. P. boiler capacity in this instance was sufficient to compress 100 ft. of air per minute to the gauge pressure of 100 lbs.

Contributing to this economical boiler capacity was the use of anthracite coal under forced draft from a steam jet, making practically perfect combustion, and a more than usually tight distributing pipeline.

Whenever a pipe line is to be determined, there is always a balance to be drawn between small size, large friction, and small first cost, and the alternate. Without pretending to any accurate determination of these features, a practical balance for this particular work was to run a main 6-in., sleeve-connected, wrought-iron pipe from the compressor, past the first shaft, and up to the second. This pipe was reduced to 4 ins. between the latter and a receiver at the north portal. A 3-in. pipe carried the line to the bottom of each shaft, and the further extension toward the several faces of attack was by 2-in. pipes resting on the bottom. Temporary connection between the end of each pipe and the drills was made by 50 ft.

of 2-in. rubber hose, distributed to the several drills by 1-in. rubber hose. The main 6-in. pipe line was laid uncovered in the streets, over and parallel to the tunnel, and was laid during hot weather. On account of its position in the street, the pipe, while slightly sinuous in detail, was very nearly straight in its general direction. Expansion bends in the pipe were impracticable on account of its location, and as expansion joints are costly and unreliable, the pipe was laid without any appliance to take up the change of length caused by variation in temperature. The line thus laid gave no trouble in passing through the changes of temperature from summer to winter, and from winter to summer.

The general method of tunneling was to carry the bench and top heading together, with the heading from 50 to 75 ft. ahead. A traveling framework, of half the tunnel width, and with the top at a lower elevation than the top of the bench, was mounted on wheels, which ran on temporary rails. The frame admitted the passage of two cars—one to be run up to the bench at its side, and the other underneath. Either car could be loaded by chutes from the platform, and, at the same time, by shoveling the bench excavation. The connections between the traveling platform and the unexcavated portion of the bench was formed with 4-in. lagging built into a plank 24 ins. wide, thus making a wheel-barrow runway between the face of the bench and the movable platform. The heading spoil was loaded into wheel-barrows, wheeled over the plank and dumped through the chute on the traveling frame, the whole operation being performed without interfering with the loading of the bench spoil.

When it became necessary to blast, the planks were simply loaded on the frame and the latter moved back on its wheels to a safe distance.

The foregoing method seems to be so simple and effective as to be scarcely worth description. Other ways of handling bench and heading material at the same time are advocated; nevertheless, the method outlined seems to the writers to be the simplest and cheapest

A peculiarity of the bench rock, in part of this tunnel, modified considerably, not only the foregoing procedure, but also affected the timbering. That peculiarity was a consequence of the combined hardness and tenacity of the bench material. To break it out required so much explosive that the rock was blown lengthwise of the tunnel with such force as to wreck any permanent timbering erected within 200 ft.. In addition, block-holing the spoil was always necessary after the first blasting. The interruption to the work of loading the heading spoil, caused by moving the traveling frame out of danger, was so serious as to render it impracticable to continue the simultaneous excavation of the heading and bench. The heading material, while requiring timber for permanent support, could be left temporarily unsupported; the support being required, not to hold up an overhead mass, but to prevent and support exfoliation, slabbing and weathering of the material. On account of these features, the heading was worked for a reasonable distance ahead, and the force then dropped back and split the bench in two lifts.

The full section of the tunnel was carried without timber support, to the extent of as much as 300 ft. The timbering was then erected from the bottom, and its full section was completed and packed from the floor of the tunnel.

DRILLING AND SHOOTING.

The longest holes were the cut holes fired first, which were from 8 to 9 ft. long. The widening holes were from 6 to 8 ft. long. The round was counted to make an advance of from 4 to 6 ft.

With two 3¼-in. machines, the time required to drill the holes was generally 7 hours. The total round drilled averaged about 140 lin. ft. The completion of the loading, wiring, firing by battery in series, reconnecting for the successive blasts, and the delay necessary between them for the explosive fumes to be blown out by compressed air allowed to escape for this purpose, consumed varying times, from 30 min. to 2 hours, or an average of, say, 50 or 60 min.

The delay from shooting was greatest in the portion of the tunnel excavated from the shafts. In this portion the fumes seemed to hang and accumulate, not only on the firing side, but also on the other side of the shaft, producing delays in both places.

The explosive was 40 to 50% dynamite, mainly the latter, and the cost per cubic yard, for explosives, caps, wires, etc., for all the excavation, was equivalent to the cost of 3½ lbs. of 40% dynamite

COMPRESSED AIR SERVICE AT NORWICH, CONNECTICUT.

Most people are familiar with the fact that compressed air is sold in Paris for power purposes, being carried under the streets through pipes. Few people, however, probably know that the same device is now available in Norwich, Conn. This has now passed the experimental stage, and has become one of the city's permanent institutions. Being the only thing of the kind in the United States and the second in the world, a smaller one having first been developed in Canada, the results of the experiment are being watched by inventors, possible patrons and investors in most of the cities of this country and many outside.

Air for the system is compressed in a Taylor Hydraulic Compressor situated at a point about 3 miles from the city on the Shetucket River and consists of a dam some 20 or 25 feet high and a shaft sunk 200 feet in the rock below the dam, ending at that bottom in an air chamber extending 100 feet up the river. This chamber being made as near air-tight as possible, the entire stream is conveyed to the bottom through a 10-foot iron pipe, on the top of which are suspended about 1,000 tubes projecting a few inches above and about five feet below the surface of the water. The falling water draws air through these tubes and carries it to the bottom of the shaft, where it is separated and directed into the chamber, while the water returns to the surface outside the pipe and is discharged into the stream, the fall from the dam giving it the necessary impetus to carry the air to the bottom and the weight of 200 feet of water giving the air its pressure.

This pressure is maintained at 90 pounds and is regulated by a six-inch exhaust pipe which discharges at the surface, projecting a stream of water, vapor and air many rods down the river with a hiss and roar that drowns every other sound in the vicinity. A Bristol recording pressure gauge displays the 24-hour record, and so well does the exhaust pipe perform its duty that the little red tracer on the dial describes an almost perfect circle. From the chamber a 12-inch iron pipe delivers the air to the city, and in spite of possible leakages, friction and use, the gauges at the city factories show little variation from a continuous pressure of 89 pounds. The loss, therefore, in conveyance to and distribution over the city is practically nothing, and as 90 per cent. of the theoretical power of the stream is found to have been carried into the chamber, this would seem the most perfect method for transforming and conveying power yet devised.

From a stream of 2,000 theoretical horse power this method is said to deliver 1,800 to the consumer at least three miles away, and the lengthening of the pipes to New London is in contemplation. As the demand for this power increases and exceeds the capacity of the present plant, more may be installed above and below on the same stream and at far less expense than the cost of the first one, said to have been between one and one-half millions. The projectors believe the capacity of the stream will equal any possible demand of both Norwich and New London.

The compressed air is sold at the rate of $3.00 per horsepower per month, but this price may be materially reduced as the power comes into general use.

Liquefaction of air is advantageously effected when the air is initially at its critical pressure of about 40 atmospheres, and is cooled by the circulation around it of air which has been cooled by expansion, but to no great extent. An arrangement described by M. G. Claude in *Comptes Rendus* is this: A tube is connected with two liquefiers and an expanding chamber; compressed air is led into this, some going to fill the liquefiers and the remainder passing into the chamber, where it is expanded to fall only to about 160 deg. Cent., passing then round the first liquefier wherein it produces liquefaction at 140 deg., to which temperature it rises itself, then passing on through a second similar expanding chamber, whereby it again falls to 160 deg., afterwards circulating round the second liquefier and acting on it as before, and finally passing away round the inlet tube and so cooling the entering compressed air. By this method 850 c.cm. of liquid air have been obtained per h.p. hour.

An innovation is a machine which takes in the heated bar of iron and makes the links either interlocked or separate, making 100 to 120 links of ⅝-inch chain per hour. It is claimed that the machine made chain is 20 to 25 per cent. stronger than chain made by hand from the same bar material.

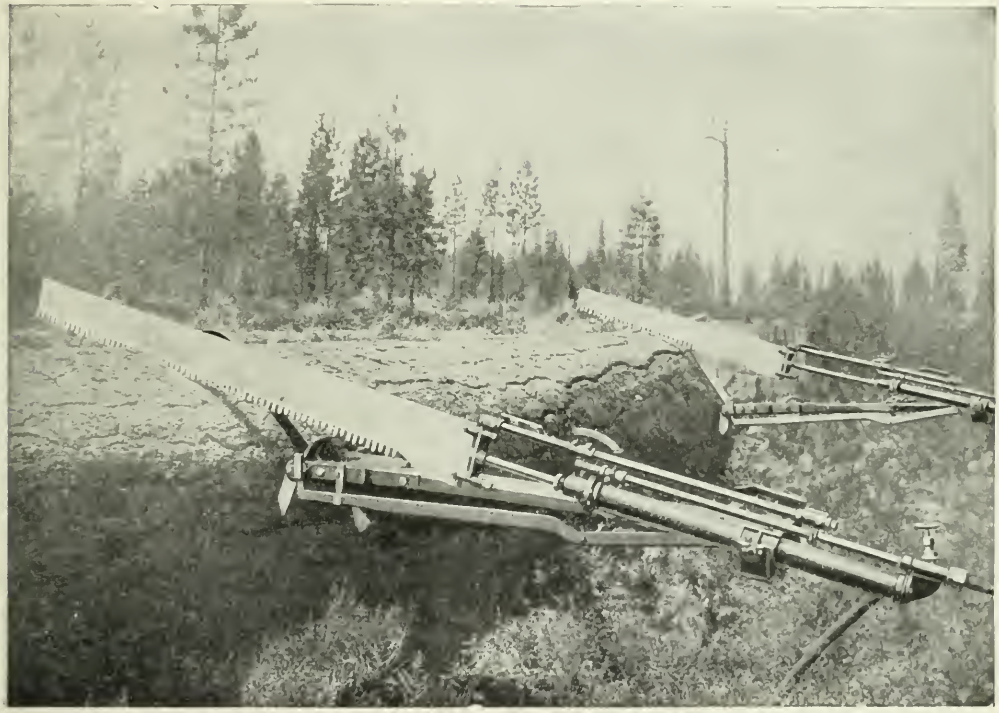
THE REDFIELD PNEUMATIC LOG-SAWING MACHINE

The saw, complete, consists of an engine, frame and saw blade. The constructive details of the machine are such, that although light in weight it is exceedingly strong and durable.

The frame serves as a hanger, and is provided with an adjustable hook to grip any size log, and requires no other support. On each side of the frame is a bar with a spring and roller attachment, the roller being applied on top of saw blade, acting as feed and guide to blade. The weight of frame complete is 85 pounds. The frame is manufactured in two sizes suitable to cut 16 in. and 24 in. lengths.

The 16 in. frame is suitable for cutting logs and stove wood, and since the engine can be operated on each side of the frame, two cuts can be made in one setting. The 24 in. frame is suited to the cutting of locomotive wood, shingle bolts, etc. An ordinary 5'-0" to 8'-0" drag saw is used in connection with this device. Owing to the adjustability of the frame, and oscillation of the engine, the saw can be operated in any position relative to the log. The frame can be raised or lowered in an instant.

The engine is constructed entirely of solid drawn brass and steel tubing. Its main feature—in addition to its weight (65 pounds)—is the tubular valve, which is perfectly balanced under all conditions, permitting the engine to work in any position. The valve motion and running gear are simple and easily repaired, hence, there is no complication of valves and parts. The tubular valve is actuated by a rocker arm that raises its motion from two cams fastened to the guide rod.



PNEUMATIC LOG SAWING MACHINE.

Weight of frame 85 pounds.

Weight of engine 65 pounds.

Capacity of saw in logs 500 per day of 10 hours.

Twenty cords of 4-foot wood or ten cords of 2-foot wood per days of 10 hours.

Ordinary working pressure required 75 pounds.

Normal number of strokes per minute 65.

Maximum number of strokes per minute 150.

Cubic feet of free air consumption at 65 strokes per minute, 33

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. NOVEMBER, 1906. No. 9.

MANY of our readers probably noticed a very obtrusive and, what must seem to them, inexcusable error which appeared at the close of our editorial, entitled "Are We Being Superseded," in the last issue of COMPRESSED AIR. This was nothing less than the omission of the sub-figure 2 in our abbreviation of carbon dioxide. We hasten to assure them that the error was not our fault, in fact, we did everything in our power to correct it. We noticed it in the first proof submitted to us and made the necessary correction. When the page proof arrived, however, the same error was in evidence, the type-setter evidently considering it beneath his dignity to trouble himself in such a small matter. We accordingly made the correction a second time and very foolishly marked the proof "O. K. as corrected" with the result that the correction never was made and the writer found himself in the enviable position of not appearing to know the difference between carbon monoxide and carbon dioxide (kindly notice that we do not venture to use chemical symbols a second time but content ourselves with plain English).

PROF. HAUPT ON TUNNELS

We publish from the Journal of the Franklin Institute some interesting notes on tunnels written by Professor Haupt. These notes are in very concise form and embody a good deal of valuable tunnel information, particularly with reference to progress and costs. Professor Haupt is qualified to speak understandingly. His father, General Herman Haupt was the engineer of the Hoosac tunnel in Massachusetts, five miles in length, begun in 1854, and generally spoken of as the first tunnel to use machine drills in its construction. The Hoosac tunnel showed the possibility of drilling rock by machinery, though it cannot be said that the rock drills used there were a success because of the extraordinary expense in repairs, which it was said only the State treasury of Massachusetts could stand. Since the days of the Hoosac tunnel the perfection of the air drill has resulted in extensive tunnel construction, the most notable instance being that of the Simplon tunnel in Switzerland, recently completed. Two systems are in use for driving tunnels by machinery—one known as the European system, by means of which heavy drills are mounted on carriages in headings, and the American system, which involves light drills mounted on columns which are jacked in the headings. It is worthy of note that in the case of the Simplon tunnel the European system has been modified and perfected to a point of extreme simplicity. The old cumbersome tunnel carriage which occupied nearly the entire area of the heading has been abandoned and a small carriage used which is no longer than a wheel-barrow and which carries a horizontal shaft bar operated by hydraulic power. The drills used in the Simplon tunnel were hydraulic machines of 30 H. P. capacity each. From 4 to 6 machines were mounted on this horizontal bar and the drilling of the holes was done in most instances with a single location of the bar in the heading; that is, this bar carrying the drills was lifted hydraulically until it reached a point approximately the center of the heading, when through hydraulic power it was jacked against the walls of the tunnel and the holes were put in at varying angles by swivelling the drills upon the bar. To do this, following the American system, would be out of the question as the holes when blasted would not bottom properly, but it worked successfully in the Simplon tunnel because the system there involved holes of 3 inches in diameter and from 3 to 4 feet only in depth. Obviously the deep hole such as we use in America in the headings, and which bottoms from 8 to 12 feet from the face, involves more care as to the exact angle at which the hole is to be put in than a hole of shallow depth. If the shallow hole will serve the purpose a great deal of time and expense is saved. Another point of advantage in the shallow hole of large diameter is that when blasting it throws the rock some distance from the heading. At Simplon they were not troubled by the extensive banking up of the muck near the heading because blasts were frequent, sometimes two and three a shift, and it was usual to run three 8-hour shifts. The shallow holes of large diameter were loaded almost to the muzzle and the rock was so scattered that it was an easy matter to bring the little carriage forward to the heading for another round. The system employed at Simplon, and the use of drills of 30 H. P., is the real reason why such remarkable progress was made there. The popular idea that this progress was due to the use of hydraulic drills is a mistake. It is due in the first place to the system employed, to the use of drills of large horse power, to the hydraulic carriage and mountings, and to the fact that having so long a tunnel to drive (12¼ miles) they reached almost perfection in doing a kind of work which was duplicated from day to day.

The American system exists to-day as it was 25 years ago. The New York Aqueduct, built twenty years ago, the longest rock tunnel ever driven in America, consisted of about thirty-one shafts separated about a mile apart each. The excavation was 16 ft. in diameter of rock section and the machinery used and its mounting was identical with that employed to-day by Messrs Pearson and others in the construction of rock tunnels under the rivers about New York. The one important advance has been in the saving in rock drill repairs, due to better design, material and workmanship in the machines. There has, however, been a distinct tendency toward the use of larger and more powerful rock drills, but there is always the limit of weight to contend with when using the American system of mounting on columns, so that American engineers in their efforts to get better work by the use of larger drills are held in check by the fact that an essential condition of the use of a rock drill in a tunnel employing the American system is that it can be lifted to its place on the column by three or four men. We look for improvement in this line by the adoption of carriages similar to those used at Simplon and by the use of percussive drills of larger diameter. Such a combination would result in the adoption of the shallow hole of large diameter as against the deep hole in the heading, and in this way the problem of mucking would be simplified.

Another improvement in sight is the adoption of the channeling process in headings in place of the cut holes. It has been demonstrated in New York City that it is perfectly practicable by the use of a machine similar to an ordinary rock drill to insert a channel directly across the heading and to a reasonable depth,—in this way making a release line toward which to direct the blasting. The importance of this in tunneling under foundations of buildings cannot be over-estimated. The channel does in a tunnel heading what it has long ago accomplished in stone quarrying; that is, it reduces to a minimum the shock of the blast, which is always greatest when discharging the center cut from the heading.

AIR DRILLS VS. ELECTRIC DRILLS.

Readers of COMPRESSED AIR will probably remember an article by Granville E. Palmer on the comparative merits of compressed air and electric rock drills, which was written for this paper and appeared in the June issue (Vol. XI, No. 4). It may, therefore, be of interest to them to know that the *Engineering and Mining Journal* reprinted this article (without, by the way, givinging COMPRESSED AIR any credit for having published it originally) with the result that a very interesting discussion has been started in its correspondence columns among mining men who have tried both types of drill.

Taken all in all, the general opinion would seem to be in favor of the air drill, although the Temple electric-air drill seems to have met with considerable favor. This drill, however, as far as the drill proper is concerned, is in reality an air drill in its simplest form and using air expansively. Speaking of this drill, Mr. H. B. Barnes states that the "Temple drill has proved quite satisfactory in the Leadville district, being used in the largest tunneling operations, in which line it has done some remarkable work as is shown by the figures given below........in drilling a round of holes in a breast of iron and zinc sulphide recently by a Temple 5A drill, the men working at ordinary rate and not under any forced speed."

Hole No. 1.	Cutting Speed.	Power.
1st steel.	4½ in. per min.	4 h.p.
2d steel.	7 in. per min.	3½ h.p.
3d steel.	8 in. per min.	4 h.p.
4th steel, 7 ft. long	7 in. per min.	4 h.p.

Speaking of the other makes of electric drills Mr. Barnes says: "In my opinion there is as yet no electric drill able to compete with the small air drills. The Box is probably the most practical now on the market for light mining, and, when given reasonably careful handling, will do good work. The personal factor enters more into the operation of electric drills than anywhere else, the careful operator being the chief necessity for successful work; unfortunately, however, he is extremely hard to find."

This, we believe, sums up in a few words the electric drill situation, as, with one exception, these drills require the most careful handling in order that good results may be obtained, and anyone who has seen the treatment that the ordinary drill runner gives his drill, will be inclined to believe that the electric drill is up against an extremely difficult proposition.

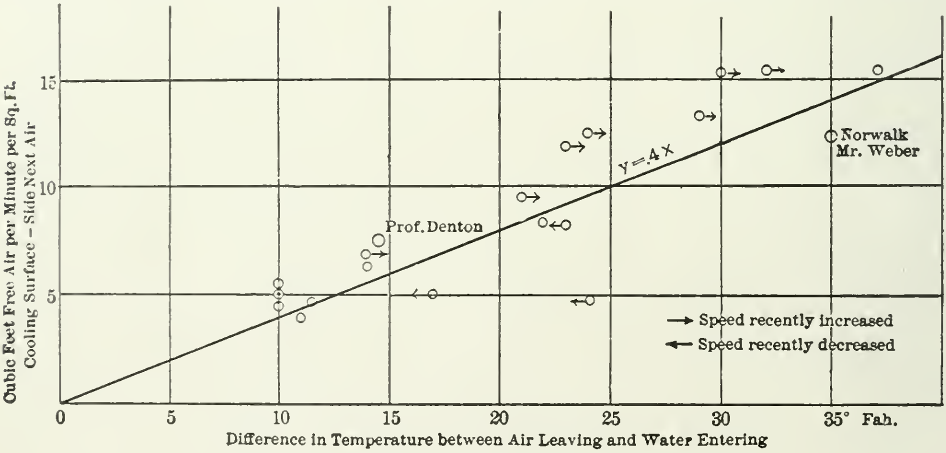


FIG. I. PLOTTED RESULTS OF THE TESTS.

INTERCOOLERS FOR AIR COMPRESSORS.

The general subject of air compressor design has received very little attention at the hands of the technical press and there is probably less reliable data available upon the subject than on the design of almost any other class of machinery. COMPRESSED AIR has always endeavored to keep its readers informed of the latest information to be had on this important subject and from time to time has published articles of importance bearing directly on air compressor design. In July, 1901, (Vol. VI. No. 5) we published a comprehensive article on the subject of valves and valve areas for air cylinders, and later have published many other articles containing information and data of value to designers and builders of air compressors. As a general rule, it might be said that the men who are in a position to write authoritatively upon the subject keep their knowledge to themselves and seldom publish facts and figures which would be of value to the designer. It is therefore of more than passing interest to note an article by Mr. H. V. Haight in a recent issue of *American Machinist*, treating of the proper design of intercoolers for air compressors. Mr. Haight was confronted with the problem of designing two air compressors of 4,000 cu. ft. of free air per minute capacity in connection with which it was guaranteed that the temperature of the air passing from the low pressure to the high pressure cylinders should be reduced to within 15 degrees of the temperature of the cooling water supplied to the intercooler. In each case there was a penalty of $150 per degree for every degree more than 15, and a bonus of $150 for every degree less than 15.

In order that some exact information might be had on the subject, a thorough test was made of a Rand two-stage machine by Mr. F. C. Weber, the results of which we reproduce in Figures 1 and 2. In this test the compressor was run but a short period at each speed, not long enough for the temperatures to come to their final values, and two sets or readings were taken, one as the speed was being increased step by step and one as it was being decreased step by step. These results were plotted, as shown in Figure 1. (Figure 2 shows the corner square of Figure 1 drawn to a larger scale.)

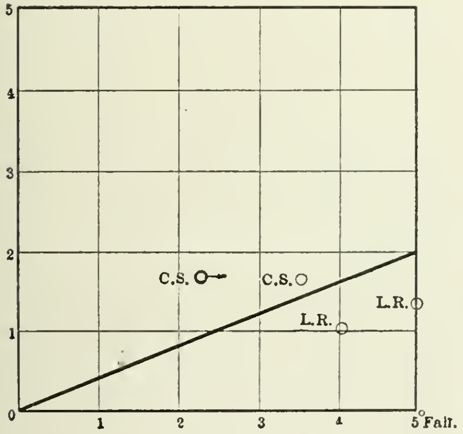


FIG. 2. TEST OF A LARGE COMPRESSOR WITH LARGE INTERCOOLER.

Mr. Haight draws a number of interesting conclusions from these diagrams, among which might be mentioned the fact that to reduce the temperature of the air to within 10 degrees of the temperature of the water requires an intercooler twice as large as one to reduce the temperature to 20 degrees above the temperature of the water, while an intercooler to reduce the temperature to 1 degree above temperature of the water would require to be 10 times as large as one to reduce the temperature of the air to 10 degrees above that of the cooling water. The quantity of heat transmitted through a given area of the tube surface varies as the square of the difference in temperature.

Another interesting point brought out by the experiments is that copper tubes are less efficient than iron tubes, presumably because copper tubes are very smooth, while iron tubes are somewhat rough, which practically increases the real area of the surface, somewhat on the principle of a pin radiator or an air-cooled automobile engine cylinder.

It is gratifying to note that from the information acquired in making the above tests, Mr. Haight was enabled to design an intercooler which reduced the temperature of the air to within 5 degrees of that of the water and so earned a bonus of $1,500 for his company.

WORKING UNDER HIGH AIR PRESSURES

Matthew Vingol, in a recent issue of the *Engineering and Mining Journal*, writes that on account of the extended tunneling operations beneath the Seine, for the various lines of the Paris Metropolitan railway, the Prefect of the Seine thought well to obtain the opinion of a committee appointed to consider the hygienic conditions of the workers in compressed-air workings, and to this end a commission, composed of Drs. Armand Gautier, Roux, Haller and Walckemar were appointed early in the year. The report of this committee has been presented to the Academy of Medicine and contains the following conclusions, which should be of interest to engineers engaged in tunneling operations:

1. That so long as work in the compressed air is done, as at present, under pressures less than 2 kg. per square centimeter above the surrounding air pressure the duration of work may be the same for the workmen as in work in the open air.

2. It would be an advantage from the point of view of the health of the tunnel workers that they be submitted but once during 24 hours to the change of pressure necessitated by work in the caissons. The duration of work should be a maximum of 10 hours consecutively, including time of entering and leaving the caissons.

3. In case it is necessary that the workmen start work twice within 24 hours a complete repose of eight hours at least is necessary between such starts. In any case overwork and accidents can only be avoided by the observance of the rules indicated below.

4. Medical inspections, periodical and frequent, are essential to verify the physical aptitude of the workers for work in compressed air, as much for new workmen as for the experience workers engaged.

5. The duration of the period of entrance and exit from the workings by stages should not be less than five minutes per kilogram pressure.

6. The exit from the pressure should always be long and progressive and such dispositions should be taken that the pressure should not be equilibrated in less than four minutes. An experienced and responsible man should be appointed to oversee the duties connected with the equilibrating of the pressure.

7. In each caisson a medical post should be established for immediate needs.

In view of the importance of these recommendations, which are subscribed to by the best medical men in Paris, it is highly probable that they will be accepted in their entirety for the compressed-air workings beneath the Seine.

TRADE PUBLICATIONS

The Chicago Pneumatic Tool Company, Fisher building, Chicago, announce the fact that they will receive from the printers their new compressor catalog, consisting of 118 printed pages, printed in two colors, in which several new types and sizes of compressors are shown, including their new Hamilton Corliss machines. Those interested will receive a copy on request. This company has also issued Catalog No. 19, devoted to Keller stone carving tools and plug drills. This catalog is handsomely illustrated, printed on heavy paper, 6x9, 50 pages.

Western Wheel Scraper Company, Aurora, Ill. New edition of their catalogue devoted to wheel scrapers, drag scrapers, Western reversible steel road machine, rock crushers, flat cars, dump cars, etc. One hundred pages, 7x10.

Willis Shaw, Chicago, Ill. Six page booklet devoted to a description of Quincy hoists, with table of horsepowers, sizes, net prices, etc.

Stanley-G. I. Electric Manufacturing Company. Bulletin 609, superceding bulletins 25 and 194, devoted to G.-I. floor and wall outlet boxes. Circular 786 devoted to the new type K arc lamps. Circular 787 devoted to direct current motors and generators. All Stanley-G. I. literature is obtainable by addressing the company at Pittsfield, Mass.

The Philadelphia Lubricator and Manufacturing Co., Inc. 1525, Land Title building, Philadelphia, Pa. Twelve page booklet devoted to a description of the Philadelphia grease cup.

C. T. Carnahan Mfg. Co., 36th and Wazee streets, Denver, Colo. Forty page booklet, 7½x5, devoted to the Murphy air hammer rock drill. Fully illustrated and containing notes on steel, automatic feeders, standards, cleaners, sharpening tools, etc.

Traylor Engineering Company, 114 Liberty street, New York. Handsome 56 page catalog, 6¾x9, devoted to stamp milling machinery, stamp mills, mortars, ore feeders, rock and ore crushers, amalgamating pans, settlers, agitators, retorts, etc.

Hardsocg Wonder Drill Company, Ottumwa, Iowa. Devoted to a description of the Little Wonder Side Valve Drill, the Little Wonder trigger valve drill, Wonder air feed drill, Great Wonder mounted drill and the Wonder air feed mounted drill. Twenty-four pages, 6x9.

The Automatic Refrigerating Co., Hartford, Conn. Twelve page booklet, illustrating and describing their automatic ammonia refrigerating plants.

Baldwin Locomotive Works, Philadelphia, Pa. Record No. 58, being a handsomely printed book illustrating and describing the ceremonies coincident to the unveiling of the statute of Mathias W. Baldwin in front of the main office building of the company.

Wier and Craig Mfg. Co., 2421 Wallace street, Chicago, Ill. Eight page booklet describing the Pilling Air Engine for turntable devices, transfer tables, portable and stationary hoists.

Western Tube Company, Kewanee, Ill. Booklet treating of a new discovery in bronze mixture known as "High Duty Metal." This metal, when subjected to high temperatures, shows a loss in efficiency of only 5.6%, while ordinary mixtures show a loss of efficiency of from 400 to 500% when subjected to the same conditions. This metal, therefore, marks a great advance over other mixtures for the use of high-speed tools.

A. & Z. Daw, 11 Queen Victoria St., London, E. C., England. Catalog 7x9½ devoted to compressed air, its production and use. This catalog contains a very thorough description of the "Daw" Patent Compressor for air and gas. It also treats of blowing engines, air washers, intercoolers, aftercoolers, air reheaters, and auxiliary plants. The catalog is well worth having as it contains many valuable curves and tables covering the theory and practice of compressed air.

Association of Licensed Automobile Manufacturers, 7 E. 42nd St., New York. Bulletin No. 18, 8½x11, setting forth this association's standard for Hexagon head screws, castle and plate nuts with many diagrams, tables and detailed specifications.

Ingersoll-Rand Company, 11 B'way, New York. Catalog No. 452B, 6x9, devoted to a description of the latest models of Ingersoll-Sergeant Rock Drills. It gives tabulated specifications of each type and size, with comments on the work for which each is adapted. A list of 44 questions covering the problems of rock drilling under all conditions is included in the book. The catalog closes with several pages devoted to tables of useful information on compressed air.

Curtis & Co. Manufacturing Company, St. Louis, Mo. Eight-page booklet 3½x6½, illustrating and describing single and double eye beam traveling cranes, light bridge cranes, low head room traveling cranes, and pneumatic hoists.

Pullman Manufacturing Company, Rochester, N. Y. Catalog 6x9, 102 pages, describing the numerous hardware specialties manufactured by this company. The catalog is profusely illustrated and contains many tables, specifications and prices.

A Hungarian physician has invented an apparatus which, producing alternate compressions of air and vacuums, causes patients who are apparently dead to breathe with all the natural motions of a live person. In the case of persons who are taken unconscious from the water or suffering from asphyxiation as a result of inhaling deadly gases, or who have ceased breathing from electric shock—in all these cases life is frequently saved after one to four hours of artificial respiration. Many deaths occur not because means of artificial respiration are not resorted to, but because people do not use proper means. To work the arms properly requires practice. This new device will do away with all this and if put in general use we may expect a lessening in the number of summer tragedies.

To the Editor of Compressed Air:

DEAR SIR:—I am in receipt of a circular from the Samson Leather Tire Co., 12 West 23rd St., New York, in which occurs the following paragraph:

"The pressure of the air inside a tube heated from 68° to 194° makes an increase of only one-eighth, viz: a tire inflated with 85 lbs. per square inch, on an ordinary temperature, will increase to 95.63 lbs. should the tire become heated as much as is possible for it to be. But this pressure will not harm the tire, which fact has been proven by our recent experiment in inflating a 920x120 (36x4½) Samson Racing Model as much as possible, which experiment has given the following result:

"The tire reached a pressure of 426 lbs. per square inch and at that point the bead became loose from the rim, but the tire did not explode."

In reading this paragraph it struck me that the figures of the Samson Company were not altogether accurate, and I accordingly made a few calculations on the subject myself which tended to confirm me in my opinion. I would greatly appreciate it, however, if you would inform me of the correct solution. I realize, of course, that the matter is of very little importance and simply desire the information as a matter of interest.

J. S. COOKSON.

The absolute pressure of air varies directly as the absolute temperature when the volume remains constant. The absolute pressure in this case is $85 + 15 = 100$ lbs. per square inch.

The absolute temperatures are:

$$68 + 461 = 529$$
$$\text{and } 194 + 461 = 655$$
$$\text{then } 529 : 655 :: 100 : x$$

From which $x = 123.81$ lbs. per square inch absolute, or 108.81 lbs. gauge, instead of 95.63 as given in the Samson circular. It is evident, therefore, that this company made an error in its calculation.

INDUSTRIAL.

THE COST OF LEAKAGE IN COMPRESSED AIR PLANTS.

Few people realize that leakage plays an important part in the efficient operation of a compressed air plant. Many concerns will go to great expense in installing high class air compressors with compound steam cylinders and two stage air cylinders, but when it comes to installing the pipe line the utmost carelessness is displayed, the same fittings being used that would apply to a steam line without the fact being taken into consideration that steam and air are two very different mediums. The heat of the steam tends, of its own accord, to keep joints tight which, if cold, would leak considerably. One has only to go into an ammonia refrigerating plant to be convinced of this fact. In such a plant special ammonia fittings are generally installed to guard against leakage in cold pipe joints. These fittings comprise a pair of flanges with a rubber sleeve held between them which is compressed when the flanges are drawn together. One would naturally believe that such a connection would be absolutely tight, but this is not always the case as there are very few ammonia plants in which the odor of ammonia is absent. How much more must this leakage be in a compressed air plant where ordinary pipe fittings are in use and where the escape of air is not noticeable to the senses and so is less likely to be detected.

In order that an estimate may be made of the cost of compressed air leakage, the following figures have been compiled to cover the compressed air plants in ordinary use, i. e., the large central power plant, the medium plant for mines and quarries, and the small plant for manufacturing establishments.

THE CENTRAL COMPRESSED AIR POWER PLANT.

This plant, while often very much larger, we will consider to have a capacity of 10.000 cu. ft. of free air per minute and assume that there is leakage of 1 per cent., or 100 cu. ft., of free air per minute. The horse power required to compress 100 cu. ft. to 100 lbs. in a two-stage compressor would be 17.6 (allowing 15 per cent. for friction in the machine). Considering the cost of this power to be 2 cents per horsepower per hour, the cost of the leakage will be 25.2 cents per hour, or $3.52 per ten hour day, amounting to $1,056 at the end of the year of 300 working days. Even if the leakage only amounted to one-half of 1 per cent., the loss would come to over $500 per year.

THE MEDIUM PLANT.

We may assume that this plant has a capacity of 1000 cu. ft. of free air per minute. If we consider the leakage to be 1 per cent., as in the first case, the loss would amount to 35 cents per day, or $105 per annum.

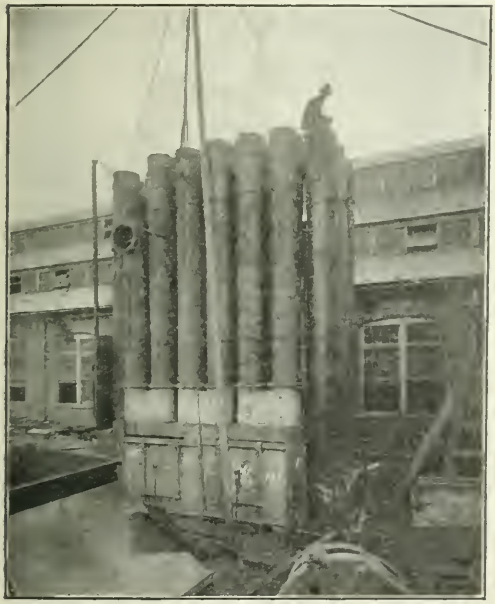
THE COMPRESSED AIR PLANT FOR MANUFACTURING ESTABLISHMENTS.

This plant is most frequently of a capacity of about 500 cu. ft. of free air per minute, but the percentage of leakage should be figured a little higher than in the previous plants, owing to the fact that more pains are taken with the larger and more expensive plants in the installation of mechinery and piping than is the case with smaller and cheaper plants. Furthermore, most manufacturing establishments require a more complicated distribution of the compressed air and the installation of more valves, bends and outlets is needed. It is therefore more fair to consider the leakage as being 2 per cent. in these cases. The compressor will very likely be a single stage one and the horsepower required to compress the leakage of 10 cu. ft. per minute to 100 lbs. pressure will be $.207 \times 10 = 2.07$. At 2 cents per horsepower per hour this leakage would cost 41.4 cents per ten hour day, or $124.20 per year.

It will thus be seen that in every plant the problem of leakage is an important one. But leakage is not the only item of expense in connection with a compressed air installation; there is also the cost of maintaining the pipe lines in good condition, replacing gaskets, tightening up joints, etc. This usually amounts to a considerable expense and should be taken into consideration by compressed air users. It is to counteract these losses that the Goldschmidt Thermit Company, 43 Exchange place, New York City, are introducing their Thermit Process for welding the joints in compressed and refrigerating pipe lines and thus produce a continuous line of pipe in which leakage would be entirely impossible and the cost of maintenance eliminated.

THE GIROUX HOT BLAST TOP.

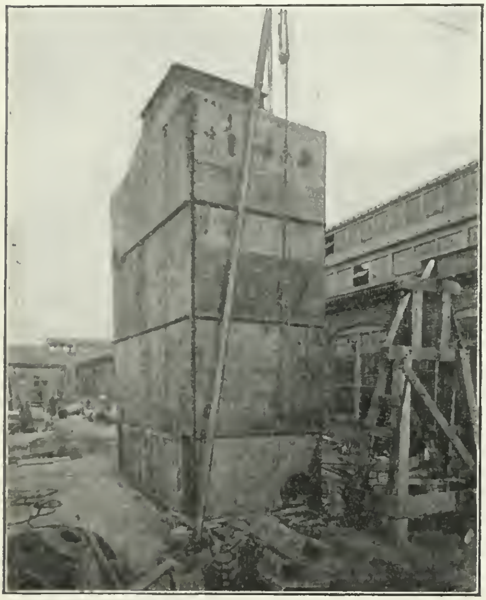
Among the recent shipments made to Mexico from the works of the Traylor Engineering Co., at Allentown, Pa., was a 42" x 160" copper smelting furnace for the National Metallurgical Co., of Matehaula. This furnace was to be fitted with a Giroux Hot Blast Top. This Top has since been completed and shipped. Illustrations of the top showing it complete, and also in process of erection, showing the internal construction, are given herewith. These are made from photographs at the Allentown works, where the Traylor Engineering Co. assembles and erects all of its machinery complete before shipment. The Giroux Hot Air Blast Top is without doubt one of the most important money saving inventions for the smelting furnace owner that has been put on the market in many years. It was developed by a practical man who knew what he wanted to accomplish, and who knew also the mechanical faults which it was necessary to avoid. Mr. Jos. L. Giroux made the invention when he was manager of the United Verde Smelter, at Jerome, Arizona. The value of utilizing the waste heat from the furnace by using it to heat the air for the blast had been fully recognized before Mr. Giroux undertook the design of his hot blast top. The value of a hot blast for increasing the efficiency of the blast furnace was also recognized, and in addition several forms of hot blast stoves of several types had been devised. The difficulty with all the previously devised forms of hot blast tops lay in the strains produced upon them by the great expansion and contraction of their parts due to the changes of temperature. This rapidly destroyed them and the cost of keeping them in repair was fully equal to any saving due to their use.



The hot blast tops first built for the United Verde Smelter have been in constant use for the last three years. They have cost practically nothing for repairs in all of that time. Since the Traylor Engineering Co. came into control of this important device its experience with the device has been equally satisfactory. Senator Clark is now having all of his furnaces at Butte, Montana, equipped with the Hot Blast Top. A year ago the Traylor Engineering Co. completed a Top of this kind for the Giroux Consolidated Mines Co., at Ely, Nevada, and this has been in constant use ever since without requiring any attention whatever. At the present time the Traylor Engineering Co. has under construction at the Allentown works the largest copper smelting furnace ever built, and this will have a Giroux Hot Blast Top. This furnace measures 46" x 255", or about 21 feet in length inside the tuyeres. It was designed by the Traylor Engineering Co., of Boundary Falls, B. C.

The Giroux Hot Blast Top is applied to the furnace immediately above the feed floor. The hot gases rising from the mass of smelting ore impinge upon the sets of pipes which form the working part of the Top and impart their heat to the air within which is fed at once to the tuyeres. The blast is heated to a temperature of 400 or 500 deg. The heat thus saved is just like finding so much fuel. It reduces the fuel charge on some ones so as to make a saving of about 30% in the fuel charge. This, however, is not all the good it accomplishes. It increases the capacity of the furnace from 15% to 25%, and also allows of the use of charges of ore carrying from 2% to 4% more silica. The hot blast gives a more uniform smelting temperature and seems to prevent to a large extent the crusting or building up on the walls of the furnace, such as is customary in general practice.

The Giroux Hot Blast Top consists mechanically of two series of metal pipes arranged symmetrically around the inside of the top of the furnace, the lower ends of one set of the pipes being just above the top of the charging door. The vertical portion of the pipes is built of sheet steel. These are circular at the bottom where they join the return elbows, and oval and of larger section at the top. The material of the pipes makes them readily permeable to the heat, and their form gives them a large surface for absorbing the heat from the furnace gases. Their form also prevents dust from adhering to them and reducing their capacity for absorbing heat. Near their tops the pipes are connected together sidewise in pairs by means of flanged cast iron connections, and at the bottoms each pair of pipes is connected by means of cast iron return elbows to form a continuous series on each side of the furnace. These elbows have a V-shaped section with one side of the V lying parallel with the side of the furnace top, and the other forming a slope for the hot furnace gases to impinge against.



The Adams-Bagnall Electric Co. announce that Mr. R. C. Campbell has been placed in charge of their Philadelphia office as special agent. Mr. Campbell is an engineer of experience and, until recently, was employed by the Curtis Steam Turbine Co., where he had charge of the tests which resulted in the design of Mr. Curtis's new marine turbine. Mr. Campbell will make his headquarters at 905 Arch street, Philadelphia, where communications addressed to him will have prompt attention.

CHIPPINGS.

IN the cylinders of a compressed-air locomotive, only a low cold-test oil should be used. The oil should show a specific gravity of about 29, and a cold test of —5° Farhenheit.

Where compressed air is carried through pipes into the mine, it should be remembered that in case of fire these pipes can be utilized to carry water into the mine. Also in case of an explosion it is sometimes possible for the men to secure air through the pipes.

Compressed air for pumping is applied in the air-lift more commonly than in any other form of apparatus. The reasons for the popularity of the air-lift are the absence of working parts in the well, low maintenance charges, assured maximum yield from any well, and the possibility of pumping a number of scattered wells from a central compressing plant.

Powder should never be taken into mines in cars propelled by electricity. In case of a wreck, the live wires are liable to come in contact with and set off the powder. In all cases the utmost care must be experienced in carrying powder to the faces.

Another argument for compressed air. The compressed air locomotive is absolutely safe.

The use of compressed air to force water or fluids along a horizontal line has generally been considered inefficient. Wherever a horizontal run must be made, it is preferable to either (1) pump the water high enough in the first place so that it may make the horizontal run by gravity or (2) raise the water by air-lift to a reservoir or tank and pump it thence by means of a pneumatic displacement pump to the desired point.

As a lubricant for air compressors, graphite has a number of attractive qualities. It is generally conceded that ignitions and explosions in compressors are due to the character and quality of the lubricant used. The best oils are likely to give off vapors and must be used sparingly. Soapsuds are also used, but must be applied in large quantities and are apt to rust the machinery when not in use. Graphite is without these deleterious qualities. It is inert, unaffected by high temperatures, and can not vaporize, ignite or cause explosion.

THE difference of cost for installation of a compressed air cleaning system in a 50 x 125 foot building of three floors, as against a building with a frontage of 150 feet with four floors and basement, is very slight, the difference only requiring extra piping. Where a store is much larger than this, a more powerful dynamo or engine would be required.

The machinery is situated in the basement. It is then necessary to pipe the building so that the openings would be sufficiently numerous on each floor for a 50-foot hose to cover the entire floor space.

The cost of equipping a store of, say 100x 125 feet, with a mechanical cleaning plant operated by means of compressed air and vacuum, would be somewhere between $700 and $1.000, but for what is known as the vacuum system only the figures would be double, if not more. Both plants require about a 7½ h. p. motor, and if the building is ten stories, a 10-h. p. motor will be necessary.

An entirely new system of street cleaning likely will be abopted by the city of Pittsburgh. Officials of the department of public works are experimenting with a modern apparatus, which may take the place of the old street sweepers and a number of "whitewings."

The downtown streets are being cleaned after each midnight with flushing machines. They have been successfully tried in Washington, St. Louis and other cities. The idea is to give them a thorough test, and if they are successful a number of the machines will be purchased.

The machine, which is simple in construction, consists of a water tank, from which the water runs, sending a spray downward that covers a space equal to one-half of a street. The water falls in such a form that it starts a current toward the gutter.

The force of the stream is gained from a tank filled with compressed air located at the front end of the vehicle. The air is sent into the tank by the force of the water as it is taken from the ordinary street hydrant.

The objection to the old-fashioned sweeper is that it never carries away all of the filth that accumulates on a street, but when the surface is wet the brooms have a tendency to pack down the mud instead of carrying it away. Should the street be cleaned with the old-fashioned sweeper before the surface has been dampened, it crates a dust that is almost unbearable.

Another advantage the flushing machines have over the old method of cleaning thoroughfares, is that it will be unnecessary for a corps of men at stated periods to wash the streets by the use of hose. It is expected that should the city adopt the flushing machines it will save thousands of dollars each year.

Three machines are now being tried. Three more from a different corporation are now on the way to Pittsburgh, and both will be given a thorough test before either is adopted. The machines cost about $1.000 apiece, but their maintenance does not cost anything. On an ordinary street sweeper it is necessary to equip them with new brooms at least once a week, which amounts to considerable at the end of the year.

WOOD PRESERVED BY HEAT.

Method Which Has Just Been Patented in France.

One of the latest methods of preserving wood has been patented in France. It has been recognized that one of the best means of preservation is to keep the wood at a high temperature in closed vessels (about 250 degrees C.) and at the same time at a high pressure, some 250 pounds per square inch. This method has been perfected by the inventor. The object of the improvements is to provide means of heating as efficacious as usual, but more practical and economical. Another aim is to utilize a part of the air pressure which has served in compressing. In the new process the pieces of wood are put in compression cylinders and the air is sent direct from the compressors into the cylinders. To heat the air each cylinder is surrounded by a masonry envelope not in contact with it, thus leaving a free space. The hot gases from a furnace are circulated in this. Cooling is effected by introducing cold air in the space. To obtain a specially good and cheap heating a series of gas jets is placed in the lower part of the air jacket and fed by a gas tube and having an air tube to aid in combustion. When the plant uses several cylinders side by side there is a saving in the work of air compression by utilizing a part of the compressed air in a cylinder at the end of the operation to send it into the next cylinder in commencing the compression here. Piping is arranged between the cylinders for this purpose.

U. S. PATENTS

ESPECIALLY PREPARED FOR

COMPRESSED AIR

827,518. LUBRICATOR FOR PNEUMATIC MACHINERY. Edwin A. Emery, Cripple Creek, Colo., assignor to The Emery Pneumatic Lubricator Company. Filed May 28, 1902. Renewed May 19, 1906. Serial No. 317,794.

827,536. AIR-CLEANING APPARATUS. George J. Kindel, Denver, Colo. Filed Sept. 26, 1905. Serial No. 280,121.

827,690. PNEUMATIC MALTING-DRUM. Franklin B. Giesler, Milwaukee, Wis. Original application filed Feb. 10, 1902. Serial No. 93,297. Divided and this application filed Nov. 15, 1905. Serial No. 287,428.

827,705. PNEUMATIC HORSE-COLLAR. John R. Burkholder, Lancaster, Pa. Filed March 16, 1906. Serial No. 306,420.

827,714. AIR-PUMP. Napoleon W. Dible, Kansas City, Mo. Filed Oct. 4, 1904. Serial No. 227,103.

827,750. BLOWING MACHINERY. Auguste C. E. Rateau, Paris, France, assignor to Rateau Turbine Company, Chicago, Ill., a Corporation of West Virginia. Filed Dec. 24, 1902. Serial No. 136,455.

827,839. AIR-BRAKE AND MEANS TO START AUTOMOBILES. Geo. W. Young, Glendale, Cal. Filed Jan. 23, 1906. Serial No. 297,456.

827,891. MEANS FOR INCREASING THE WORK OBTAINABLE FROM A CHARGE OF COMPRESSED AIR. William H. Sodeau, Newcastle-upon-Tyne, England, assignor to Sir W. G. Armstrong, Whitworth and Company, Limited, Newcastle-upon-Tyne, England. Filed May 9, 1905. Serial No. 259,580.

Claim. The combination with apparatus for heating a body of compressed air of the type in which liquid fuel is fed into the compressed air by the expansion of a second body of compressed air, of means for allowing part of the second body of compressed air to escape before the whole of the fuel has been delivered.

827,926. MEANS FOR INFLATING RUBBER TIRES. Alfonso G. Lavertine and James E. McNellan, Johannesburg, Transvaal. Filed Oct. 10, 1905. Serial No. 282,109.

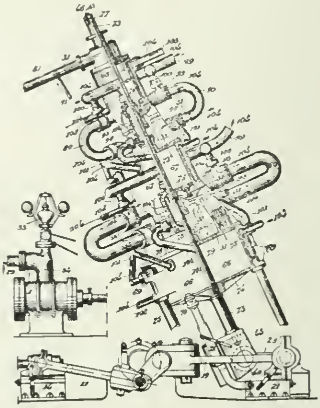
827,927. PNEUMATIC TIRE. Henry D. B. Lefferts, Orange, N. J. Filed Nov. 17, 1905. Serial No. 287,805.

828,254. TIRE. James H. Swain, Pittsburg, Pa., assignor, by mesne assignments, to H. M. & S. Armored Tire Company Incorporated, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Aug. 14, 1905. Serial No. 274,123.

828,270. APPARATUS FOR MAINTAINING AIR-PRESSURE IN ALE AND BEER CASKS. Edward R. Brown, Boston, Mass., assignor, by mesne assignments, to Wilber F. Lakin, trustee, Quincy, Mass. Filed June 4, 1901. Serial No. 63,058.

828,295. COMPRESSED-AIR MOTOR. Ivan W. Ammon, St. Petersburg, Russia. Filed Sept. 24, 1903. Serial No. 174,411.

Claim. The combination in a motor operated by compressed and heated air of three cylinders in which the compressed and heated air expands successively, of a crank-shaft, driven through connecting-rods by the piston-rods of the driving-pistons, two air-compressors, operated by means of connecting-rods by the said main shaft, the axial line of each of these compressors making a suitable angle with the working axial line of the cross-head operating the pistons of the corresponding compressor by means of a connecting-rod, the length of this connecting-rod, the stroke of the compressor-piston and that of the cross-head being equal, as described and shown.



828,432. MEANS FOR INCREASING THE WORK OBTAINABLE FROM A CHARGE OF COMPRESSED AIR. William H. Sodeau, Newcastle-upon-Tyne, England, assignor to Sir W. G. Armstrong, Whitworth and Company, Limited, Newcastle-upon-Tyne, England. Filed May 9, 1905. Serial No. 259,581.

Claim. The combination of a reservoir for compressed air, a reservoir for fuel, a pipe having one end in the air-reservoir and the other end standing up in the lower part of the fuel-reservoir, the latter end being perforated with two or more holes at different heights, and means for igniting and burning the fuel in the air-reservoir.

828,498. AIR-FEEDING DEVICE FOR STEAM-GENERATORS. Charles D. Mosher, New York, N. Y. Filed July 17, 1903. Serial No. 166,055.

828,522. AIR-COMPRESSOR. Theodore H. Smith, San Francisco, Cal. Filed May 27, 1905. Serial No. 262,623.

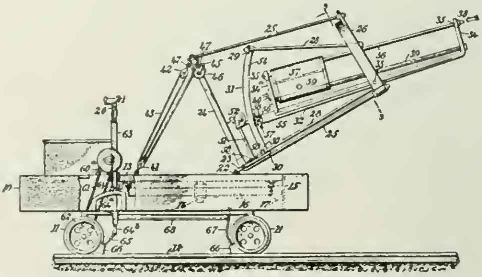
828,590. APPARATUS FOR INTRODUCING POWDERED ELEMENTS INTO CASTINGS. Frank G. Wright, Indiana Harbor, Ind., assignor to American Steel Foundries, Chicago, Ill., a Corporation of New Jersey. Filed Feb. 23, 1906. Serial No. 302,420.

828,592. CENTRIFUGAL FAN. William E. Allington, Saginaw, Mich. Filed Jan. 30, 1905. Serial No. 243,204.

828,635. AIR-BRAKE SYSTEM. Newton R. Beauchamp, Atlanta, Ga. Filed April 20, 1906. Serial No. 312,872.

828,641. TIRE FOR MOTOR-CARS. Isidore Clifford, London, England. Filed Aug. 4, 1905. Serial No. 272,748.

828,684. ROCK-DRILL. John E. Sales, Wrangell, Alaska. Filed May 10, 1905. Serial No. 259,740.



Claim. In a rock-drill, a car, a turn-table on the car, a main frame pivoted to the turn-table, means for adjusting said frame, a secondary frame pivoted in the main frame to swing in a plane at right angles to the plane of movement of the said frame, means for adjusting the secondary frame, a supporting-bar pivoted in the secondary frame to swing in a plane at right angles to the plane of movement of the secondary frame, said bar carrying guide-rods, means for adjusting the supporting-bar, a motor mounted to slide on the guide-rods of the supporting-bar, and means for sliding the motor on said bars.

828,781. PNEUMATIC CUSHIONED STOOL. Chester Smith, Oak Hill, Ohio, assignor of one-half to David E. Evans, Oak Hill, Ohio. Filed March 9, 1906. Serial No. 305,167.

828,827. ELASTIC-FLUID TURBINE. James C. Prescott and Henry A. Prescott, Philadelphia, Pa. Filed Sept. 25, 1905. Serial No. 280.015.

828,861. SHAFTING FOR CAISSONS AND THE LIKE. Daniel E. Moran, Mendham, N. J., and John W. Doty, New York, N. Y. Filed April 4, 1906. Serial No. 309,850.

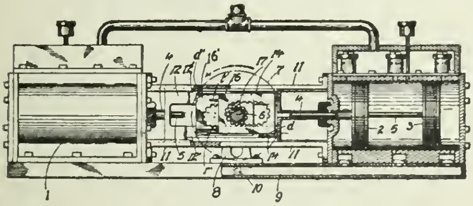
828,939. AIR-PRESSURE BRAKE. Erwin Kramer, Berlin, Germany. Filed Aug. 3, 1904. Serial No. 219,402.

829,143. AIR-BRAKE SYSTEM. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Dec. 29, 1905. Serial No. 293,753.

829,712. PLASTIC-MOULDING MACHINE. William S. Godwin, New York, and Charles I. Williams, Utica, N. Y. Filed Feb. 2. 1905. Serial No. 243,792.

829,707. MACHINE FOR TREATING AIR. John W. Fries, Winston Salem, N. C. Filed Sept. 28, 1905. Serial No. 280,437.

829,441. AIR PUMP OR COMPRESSOR. Charles O. Sobinski, St. Louis, Mo. Filed Dec. 19, 1904. Serial No. 237,538.



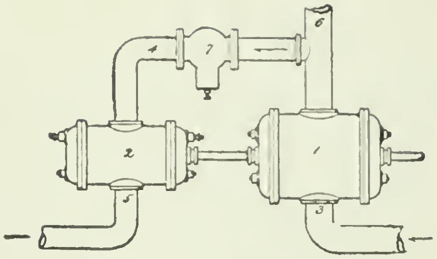
Claim.—1. In a pump, a pair of juxtaposed cross-heads simultaneously reciprocating in opposite directions formed on their adjacent faces, interiorly-toothed plates confined in said depressions and susceptible only of a movement therein at right angles to the axis of reciprocation of the cross-heads, a tongue and grooves and a rib between the grooves formed on each plate, the tongue oof one plate operating in the groove on either side of the rib on the opposite plate, a drive-shaft, and a pinion on the shaft engaging the toothed surfaces of the openings of the plates, the parts operating substantially as, and for the purpose set forth.

830,433. PNEUMATIC DISCHARGING DEVICE FOR LIQUIDS. Isaac W. Heysinger, Philadelphia, Pa. Filed Aug. 21, 1905. Serial No. 275,066.

829,941. PNEUMATIC FOR MUSICAL INSTRUMENTS. Jacob Binning, Boston, Mass., assignor of one-half to Mason & Hamlin Company, Cambridge, Mass., a Corporation of Delaware. Filed July 10, 1905. Serial No. 268,912.

830,503. COMPOUND AIR-COMPRESSOR. Ebenezer Hill, Norwalk, Conn. Filed Aug. 18, 1905. Serial No. 274,657.

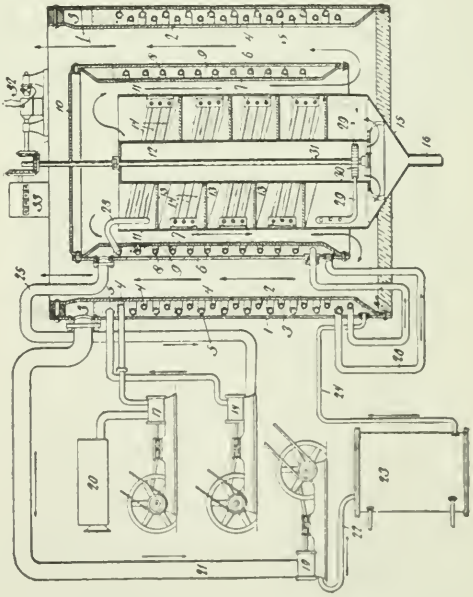
Claim.—1. The combination in a compound compressor of a low-pressure cylinder, a high-pressure cylinder, a duct connecting the discharge of the low-pressure cylinder with a choke-valve in the duct between the cylinders arranged to open and close the passage through the duct according to the pressure in the duct between said valve and the low-pressure cylinder, substantially as specified.



830,538. PNEUMATIC VANNER. Albert H. Stebbins, Little Rock, Ark. Filed Aug. 19, 1904. Serial No. 221,424.

Claim.—1. In a machine of the class described, the combination of a main supporting-frame, a belt-carrying frame mounted to swing from said main frame, an inclined concentrate-belt formed of sheet metal and carried by said belt-carrying frame, said sheet-metal belt having perforations, the walls of which are disposed to direct fluid-currents over and substantially parallel to said belt, and a fluid-chamber beneath the upper run of said belt for directing fluid-currents through said perforations.

830,613. APPARATUS FOR LIQUEFYING AIR AND OTHER GASES. Raoul P. Pictet, New York, N. Y. Filed Jan. 12, 1901. Serial No. 42,951.



Claim.—1. In an apparatus for liquefying air and other gases the combination with a series of cooling vessels adapted to contain liquid refrigerants of successively lower boiling-points, each provided with cooling-pasages, for conveying the gas to be liquefied through said cooling vessels, such passages of the said vessels being connected in series, and the vessel for containing the refrigerant of higher boiling-point having other cooling-passages connected with the vessel for containing refrigerant of lower boiling-point, and forming cooling-passages for the refrigerant of lower boiling-point, of means for compressing the vapor of the refrigerant of lower boiling-point, and for passing it through the corresponding cooling-passages of the vessel containing the refrigerant of higher boiling-point.

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DECEMBER, 1906.

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THE GUNNISON TUNNEL OF THE UNCOMPAHGRE IRRIGATION PROJECT

By M. G. DOLL.*

It is only by close acquaintance with some specific undertaking, such as the one described in this article, that it is possible to realize the extent of the work being done by the U. S. Reclamation Service. The Uncompahgre project is but one of dozens of irrigation systems which are being developed throughout the West. Some of these are larger in extent and more important in their results than this, but from an engineering standpoint, none is of greater interest. The driving of a tunnel nearly six miles in length through materials ranging from soft mud to hard rock is a large enterprise, particularly when it is remembered that owing to the height of the hill penetrated, nearly five miles of the tunnel are being driven from two headings, one at each end, without intermediate shafts for ventilation and removal of excavated materials. This tunnel is the longest, although not the largest in point of diameter, in the United States, and as far as the writer's information goes, it is the longest in the world, driven as above described from only two openings and without intermediate shafts. The methods and the progress made, as described below, reflect great credit upon the skill and executive ability of the government engineering force in charge of the construction.

VIEW FROM TOP OF SHAFT FOR HEADINGS 2 AND 3.

THE IRRIGATION PROJECT.

The Gunnison Tunnel is part of the Uncompahge Valley Irrigation Project, undertaken by the United States Reclamation Service. This project when completed will reclaim about 150,000 acres of land, in the Valley of the Uncompahgre river, in a portion of Montrose and Delta counties, in the west central part of Colorado. (See general map.) Small portions of the Uncompahgre Valley have been under irrigation for some time, by water drawn from the Uncompahgre river, but owing to the limited supply of this water, the irrigation necessarily had to be restricted to a small area. However, these preliminary experiments served to show the possibilities of this land, if it could be supplied with a sufficient amount of water.

The soil in the Uncompahgre Valley is practically of two kinds, an adobe on one side and a sandy soil on the other. The adobe has proven to be adapted especially to wheat and other small grains, in general, while the sandy soil is more strictly adapted to fruits, potatoes and sugar beets. The productive season of this section has been in the past rather long, spring opening early and the autumn frosts coming late. These facts, coupled with the large choice of crops, should not only make the project a thorough success, but they should also make this one of the ideal sections of the State for homesteads.

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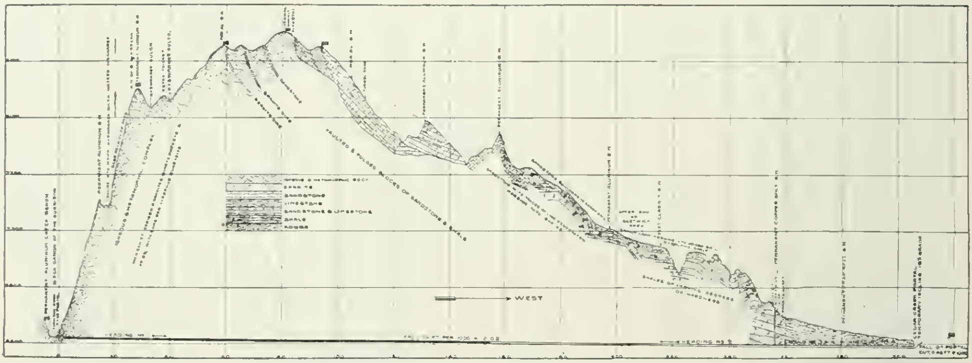
*1748 Broadway, Denver, Colo.

To accomplish this condiiton of affairs it was calculated that an additional water supply of 1,300 cubic feet per second, during the productive season, would be necessary. Records of the Gunnison river showed that an average maximum flow of 14,200 cubic feet per second occurred in June and a minimum of 750 cubic feet per second in September; during April of this year there was an average flow of 1,481 cubic feet per second. The Gunnison river, therefore, carried sufficient water to furnish the necessary supply for the Uncompahgre Valley project, but it was locked in one of the characteristic cañons of Colorado, with nearly perpendicular walls of solid rock about 1,500 feet in height. After a thorough investigation on the part of the Reclamation Service, it was finally considered feasible to divert the water from the Gunnison cañon by running a tunnel nearly six miles in length under Vernal Mesa.

Work was begun on this tunnel in February of 1905. On July 1st, 1906, the total distance driven was 13,767 feet, of which 1,321 feet were completed during the month of June. At the present time it is expected that the work will be completed, with the exception of a part of the concreting in the solid rock portion, so that the flow of water through the tunnel may begin in the spring of 1908. The remainder of the concrete construction will be completed during the winter of the same year. During subsequent years it is intended to maintain a full water supply from April 1st to October 1st. A diminished flow will be maintained for cattle water for some time previous to April 1st and continued for some time after October 1st. The cost of the entire project, complete, is estimated at $2,500,000.



PROFILE OF THE GUNNISON TUNNEL.
(Redrawn from the Government Map) Horizontal scale 1 inch = 4125 feet; Vertical scale, 1 inch = 735 feet.

THE TUNNEL—GENERAL FEATURES.

The east or river portal of the Gunnison tunnel is situated in the cañon of the Gunnison river, in Montrose county, altitude (grade line of the tunnel at Section No. 1) 6,533 feet. (See general and profile maps.) The grade line of the tunnel is about 6 feet below the lowest point of the bed of the river. At the present writing, the plans and specifications for the controlling gates have not been passed upon. The total length of the tunnel from the east to the west portal will be 30,582 feet, with a fall of 2.02 feet per 1,000 from the east to the west portal. It is designed to have a capacity of 1,300 cubic feet of water per second with a velocity of 12.6 feet per second.

The tunnel is ten feet in width at grade, with walls slightly sloping to the base of the arched roof or invert, where it is 11 feet wide. The height from the floor to the highest point varies from 11 feet 5 inches to 12 feet. The greatest depth from the surface of Vernal Mesa to the tunnel is 2,200 feet. The accompanying profile map and cross section of the tunnel at different points indicate the extent and character of the undertaking.

The postoffice name of the camp at the east portal is River Portal; that at the west end of the tunnel is Lujane. They are connected by a government road about 12 miles long, passing over Vernal Mesa. This road and a general view of the Mesa are shown in the accompanying illustrations. The building of this road was an engineering feat in itself, especially on the River Portal side, where the walls of the cañon are extremely steep and rugged, the summit being nearly 2,000 feet above the river.

THE EAST, OR RIVER PORTAL; TO THE LEFT IS THE HOIST HOUSE.

THE DISTRIBUTING CANALS.

From the West Portal, 1,250 second-feet of the water will be carried through a cement-lined canal (50 second-feet having been diverted to Cedar creek near the portal) to the Uncompahgre river, where a number of branches are made, the bed of the Uncompahgre river also being utilized to convey a portion of the water. As the grade from the West Portal to the Valley is quite steep, it will be necessary to lower the water by gradual stages, so that the walls and bed of the canal may not be destroyed by the velocity of the flow. This fall is accomplished by a series of 14 steps, which are so placed as to cause the water to fall on a grating of 80 pound steel rails, spaced 8 inches apart, the rails being held in place by a double concrete arch. This grating serves to break the force of the fall and also to catch any debris which may be carried down the canal. From this grating the water falls into a basin of sufficient depth to form a water cushion, thus preventing any damage to the concrete lining.

TUNNEL CONSTRUCTION—MATERIALS ENCOUNTERED.

The main tunnel was driven from four separate headings (see profile map), No. 1 at the east portal, Nos. 2 and 3 from a 200-foot shaft which was sunk about a mile from the west portal, and No. 4 from the west portal of the tunnel. Nos. 3 and 4 have since met, thus leaving work at Nos. 1 and 2 in active operation at the present time. Heading No. 1 was driven in a hard rock formation from the beginning, while the materials in Nos. 2, 3 and 4 vary from a soft adobe mud in No. 4 to a very soft, extremely brittle shale in No. 2. The ground in No. 4 and the latter part of No. 3 just previous to the junction of Nos. 4 and 3 consisted of a soft swelling adobe mud.

The sections of the tunnel running through the mud and soft shale were timbered with eight and twelve inch pine timbers, and the whole tunnel section is lined with concrete.

METHOD IN EARTH AND SOFT ROCK SECTIONS.

Heading No. 2 and the first part of No. 3, in soft shale, were advanced by a bench and overcut heading system, employing air-driven rotary drills or coal augers. With a few exceptions, where the ground was firmer than ordinary, the timbers were advanced by the crown bar system, which consisted in carrying the roof on temporary stringers held in place by jack-bars, until the permanent timbering could be finished. Very rapid work was accomplished in this ground, in a few cases over 600 lineal feet being driven during one month.

The muck from headings Nos. 2 and 3 was hoisted through the shaft, located at their starting point, while that from No. 4 was hauled in side dump tunnel cars, holding 1¼ cu. yds. each, through the west portal and run out on a dump at the side of the main canal. In heading No. 2 the tunnel has recently passed through a deposit of sea shells, some of which were three and four feet in diameter. These shells sometimes fell without warning, bringing down masses of shale from the roof of the tunnel.

During the latter part of July of this year, the hoist originally used for headings Nos. 2 and 3 was put out of commission, and the muck from No. 2 heading is now being carried through the west portal of the tunnel. This is a very economical operation, as the loaded cars are carried on the down grade, therefore the amount of muck moved by the mine locomotives depends largely on the number of empty cars the locomotive is able to haul up the grade. At the foot of the shaft a large room has been constructed. It is intended to install one of the concrete plants in this room, and divide the shaft into two compartments, to be utilized for supplying by gravity feed the gravel and sand used in the concrete. A very good grade of these materials is obtained from the Mesa in the near vicinity. The concreting will be simultaneously begun in a number of places in the west portion of the tunnel, as soon as the mixing machinery can be installed.

TOWN OF RIVER PORTAL AND THE GUNNISON RIVER; THE SMALL CROSS ON THE LEFT BANK INDICATES THE EAST PORTAL OF THE TUNNEL.

EAST PORTAL—ROCK CONSTRUCTION.

In heading No. 1 (driven from the east portal) a different condition of affairs exists. This heading has been in very hard rock ever since the beginning of operations, and from all indications it will probably continue so until headings Nos. 1 and 2 meet.

Owing to the fact that the grade line of the east portal is six feet below the bed of the river, it was necessary to make an opening above the high-water mark of the river, and then drop sharply to the grade line. This causes a short, steep incline, at the mouth of the tunnel, which necessitates the use of a small hoist, for hoisting and lowering the electric locomotive and the two-yard loaded muck cars. These cars are handled on the dump by a stiff leg derrick designed and built on the ground by the government engineers. (See cut, page 4288).

THE WEST PORTAL AND TOWN OF LUJANE.

The rock work at the east portal was begun by contract. Under the supervision of the contractors the work was advanced by an undercutting drift, the roof being subsequently shot down. Owing to this method, and to deficiencies in equipment, as will be shown below, progress was unsatisfactory and the contractors abandoned their task. The work was then taken up by the United States Reclamation Service, and overcut heading and bench work was installed. Since this time the work has been making very satisfactory progress.

As mentioned above, the height of the hill over the tunnel prevents the sinking of a shaft for ventilation and removal of materials. Ventilation is provided by means of powerful blowers at either end of the tunnel, and no trouble has been experienced on this score. All materials excavated are removed through the tunnel itself. The method employed in the west heading has already been described. From the river heading the muck cars are run to the bench on a double track, the forward cars being filled by the bench muckers and the after cars by the heading muckers. The muck from the heading is carried to the rear cars on wheelbarrows, over the bench and onto a gang plank, supported above the cars on long mining bars. This method of driving a tunnel has shown its merits and proven its practicability in its more rapid advance and in lower cost of operation, as demonstrated by complete records of these details for both systems, kept by the engineering force.

ROCK DRILLING.

The original contractors had installed a Leyner air plant with Water Leyner drills, and the use of this plant was continued under the new system. Four Leyner drills were used in the heading and two on the bench. In February of this year, Mr. W. H. Davis, a tunnel man of experience, was appointed superintendent of heading No. 1. Shortly before April 1st Sullivan standard three-inch drills were substituted for the Leyner machines. This change produced a marked increase in the progress of the tunnel, as well as a considerable saving in the cost of drill repairs, even though the rock became continually harder as the tunnel advanced. It was also found that four Sullivan drills in the heading with one on the bench, were sufficient to successfully carry on the work. The following tables, compiled from the records kept by the government engineers, will give an idea of the progress made up to date.

THE BLACK CANON OF THE GUNNISON.

The following results were tabulated from a special report in the engineer's office, comparing the relative cost of the rock drill repairs on the Leyner drills, for a period of six months, from September 1st, 1905, to March 1st, 1906, with those on the Sullivan drills for a period of three months, from April 1st, 1906, to July 1st, 1906. These costs are simply for the repair parts required for the drills, the cost of the steel used, and of the time required by the mechanic in making the repairs:

Cost per lineal foot of completed tunnel section, for Leyner drills.......	$4.65
Cost per lineal foot of completed tunnel section, for Sullivan drills......	.86
Cost per lineal foot of holes drilled, for the Leyner drills	.31
Cost per lineal foot of holes drilled, for the Sullivan drills	.03

The engineer's records also show the average cost of repairs, steel and labor for one Sullivan drill per month to be approximately 29 per cent. of the cost of repairs for one Leyner drill per month.

POWER PLANTS AND EQUIPMENT.

The power plants at Lujane and River Portal are constantly changing as the work advances. The former has a tendency to decrease in extent, owing to the smaller number of headings being supplied with power, and to the fact that the grade of the tunnel is toward the west portal. The plant at River Portal, conversely, has a tendency to increase. At the present writing the Lujane plant proper comprises three electric generators rated at 275 kw., which operate three high speed engines; two straight line and one cross compound steam driven compressors with a total capacity of 1,600 cubic feet of free air per minute, and boilers of 500 H. P. capacity. In this end of the tunnel are installed suitable pumps, a 75 H. P. air hoist, two 25 H. P. blowers, and three electric mine locomotives, with a large number of 1¼ yard dump cars. A number of air-driven coal augers are also in use.

At River Portal the plant comprises the following machinery: One 1,000-foot straight line compressor, and one cross compound, two-stage compressor with a capacity of 600 cubic feet of free air per minute. The air pressure used throughout the tunnel is 100 pounds. Two 100 H. P. engines are driven each by a 75 k. w. 250 volt D. C. generator, and one 55 H. P. engine is driven by a [illegible] kw. D. C. generator. Steam power is supplied by three 80 H. P. horizontal tubular high pressure boilers, and one 100 H. P. boiler. A suitable equipment of pumps and condensers is installed. In the east tunnel there are in use, two electric mine locomotives, an adequate number of dump cars, one 50 H. P. hoist with a 3 ft. 6 in. clutch-driven drum, and a blower with a capacity of 5,000 cubic feet of air per minute, which is used for ventilating purposes, the air passing through an 18-inch sheet iron ventilator pipe. Eight Sullivan class UD drills are also in use in this heading, five of which are used in driving the tunnel and three kept in reserve. Thirty-pound rails are used for the tunnel track. and the entire length of the tunnel is lighted with 16-candle-power electric lamps, with arc lights in the headings.

TABLE No. 1

Month, 1905	Mar.	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
*Number of lineal feet of full tunnel section completed	53	....	....	....	....	....	....	....	....	....
Number of lineal feet of heading completed.	....	153	312	165	252	384	355	228	225	181
Geological Formation.	Surface Ground	Hard Schist with Rotten Mica	Hard Schist with Rotten Mica	Gneissoid, hard and dry	Geneissoid Granite	Geneissoid Granite	Gray Granite and Pyritic Quartzite.	Gneissoid Granite	Geneissoid Granite	Rock very brittle with Blue Quartz

*No separate record was kept of the full section of tunnel finished during 1905; full credit was given during each month for the amount of under-cut drift made, but during some of this time the back roof was as much as 1,000 feet behind the face of the drift.

TABLE No. 2

Month, 1906	Jan.	Feb.	March	April	May	June
Number of lineal feet of full section completed.	118	184	234	300	383	373
Number of lineal feet of heading made.	126	204	236	300	377	381
Geological Formation.	Pink to a rotten Granite with schist bordering on soft mud	Hard Mica Schist	Varied to a very hard Granitic Gneiss	Varied from hard Granitic Gneiss to Pink Granite	Short grain and tough very hard to drill	Pink Granite

LABOR AND LABOR CONDITIONS.

The camps at River Portal and Lujane are notably well equipped and well built, both from a sanitary point of view and for the comfort and entertainment of the employes. There are a few tent houses, but most houses are boarded, and both the sides and roofs are covered with roofing paper, which makes a house warm in winter and comparatively cool in summer.

Each camp is equipped with a small but complete hospital in charge of a competent force of trained nurses. All houses are lighted with electricity and connected with a town water supply. A well-organized commissary is operated by the government, also a large boarding house, provided with a large, roomy, well-ventilated sanitary kitchen, where the unmarried men are given board. Besides all these necessaries of life, the government also provides a large, well-lighted and ventilated reading room, a town hall where entertainments, dances and concerts may be held, and also a billiard room. The streets are kept thoroughly clean, and quite a number of the family houses have small grass plots and flower gardens in their door yards.

The writer wishes to express his obligations to Mr. I. W. McConnell, the constructing engineer in charge, for the courtesy and assistance rendered in obtaining the necessary data for this article, also for the favors extended by members of his engineering staff.

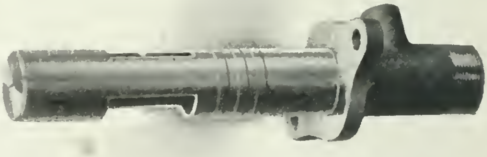
DERRICK FOR DUMPING CARS, RIVER PORTAL.

TURBO-BLOWERS

In a paper recently presented at a meeting of the British Association for the Advancement of Science by Gerald Stoney, on the subject of "Recent Advances in Steam Turbines —Land and Marine," the author described the development of the steam turbine for driving rotary air compressors of the turbine type, which are now being used largely for blowing blast furnaces. The advantages gained are light weight, small foundation, small consumption of oil and above all, high economy of steam over the reciprocating types of blowing engines. The outfits described are generally for about 20,000 cubic feet of free air per minute, and a pressure of ten to fifteen pounds per square inch. A slightly different type is made for about 30,000 cubic feet per minute, at about one pound per square inch pressure. These blowing equipments are being used in several large iron works for dealing with the waste gases from furnaces and for driving these gases through the recovering plant, etc., an important feature being that they do not clog with tar and other matters. Since it is nearly impossible to use economically low-pressure steam at about atmospheric pressure in a reciprocating engine, the exhaust steam turbine becomes an important factor in those cases where there are non-condensing engines and other sources of exhaust steam.

A NEW ROTARY AIR COMPRESSOR

It will probably be of great interest to users of compressed air to know of a new air compressor which, although the pistons reciprocate in the cylinders, might be termed a rotary compressor. The rapidly increasing use of compressed air, due to the development of new applications and to the improvements in air motors and air tools, has brought out a large number of compressors, nearly all of which, however, are of the same general design and construction. Anything new, therefore, in air compressor design, is of more than ordinary interest, and we believe our readers will be particularly interested in a new type of machine which is illustrated by the accompanying cuts. This machine has many advantages over the prevailing reciprocating type as will be seen from the general construction as described below.



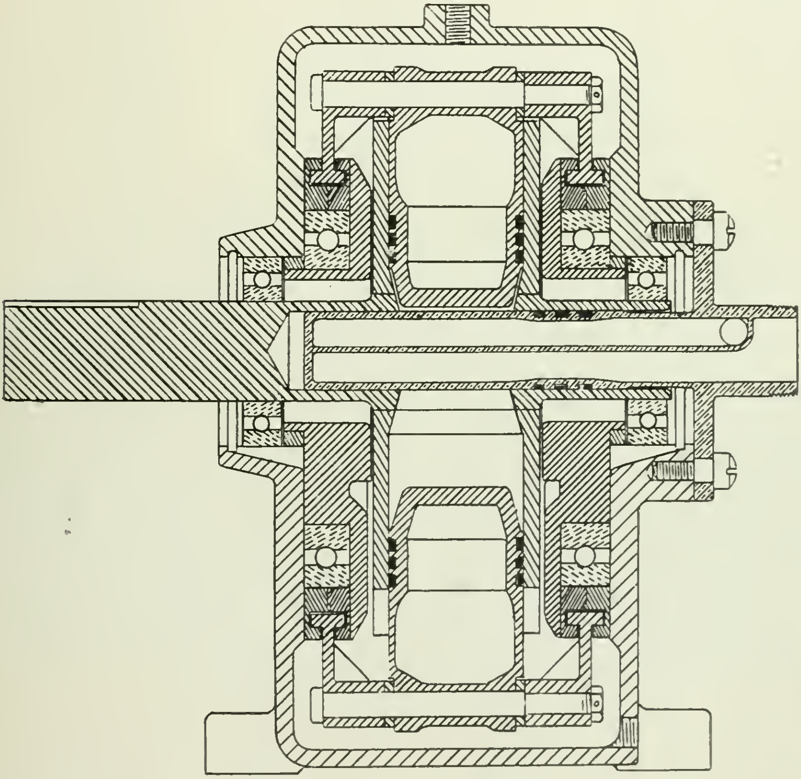
VALVE REMOVED FROM THE SHAFT.

In general outline the machine resembles an electric generator. By removing the upper portion, the entire mechanism is exposed for examination and repair. Where belt power is used for driving a compressor, a belt tightening sub-base is furnished. This in itself is an advantage never before attained in compressor work.

The cylinders are of cast iron completely water-jacketed, and are single acting, radiating from a hollow steel shaft on which the cylinder casting is secured. Each cylinder has a single port at its inner end communicating with the interior of the shaft. These ports are very large in proportion to the cylinder capacity, allowing for a large intake volume without wire drawing, the shaft being hollow, the intake and exhaust air passing through the valve therein contained as below described.

The ~~cylinders~~ Pistons are cast hollow to reduce their weight to a minimum and they are packed with the ordinary type of snap rings; furthermore, they are furnished with projections on their inner ends which fill the ports completely, thus making the clearance space only 2 per cent. in the smallest sizes of compressors. They are suspended at their outer end by wrist pins in independent yokes which revolve around a bearing eccentric to the shaft bearing on which the cylinders turn.

Ball bearings are used for the main shaft and the eccentric bearing, this construction being made possible by the fact that they are not subjected to sudden strains or shocks, all motions and stresses being straight, steady and uniform.



LONGITUDINAL SECTION OF COMPRESSOR.

The inside of the hollow shaft forms the valve seat. The valve is of bronze and is divided into intake and exhaust chambers by a partition. Each chamber has a port at its inner end and a pipe connection at its outer. The valve is anchored to the case, so that as the shaft revolves around it, the cylinder ports pass over the intake port during the outward motion of the piston in the cylinder. At the extreme end of the outward stroke intake is cut off and, as the piston is forced back into the cylinder, the air is compressed to approximately the receiver pressure, at which time the cylinder port passes over the discharge port and the air in the cylinder is expelled. The different periods of admission, compression and discharge are automatically accomplished by the revolution of the shaft around the valve. The valve automatically seats itself because of the pressure on the discharge side forcing it against the intake port. Longitudinal leakage is prevented by snap rings running in grooves in the valve.

The cylinders are thoroughly water-jacketed and, on account of the multiplicity of single acting cylinders, a much greater cooling surface per cubic foot capacity is obtainable than in the ordinary double-acting type of compressor. This, of course, greatly increases the efficiency.

An idea of the simplicity of this machine may be acquired by glancing at the following complete list of parts which go to make up any size of this compressor:

Case, bottom; case, top; 8 cap screws; 1 shaft with cylinders; 4 pistons; 8 yokes; 4 wrist pins; 2 bearings, shaft; 2 bearings, eccentric; 1 drain cock for oil; 2 water connection bolts (hollow); 1 valve; 2 anchor screws for valve; 2 water rings; 1 sub-base complete.

Other important advantages possessed by this compressor are its light weight and perfect balance, enabling it to be operated without being mounted on special foundation. The large intake and port areas in proportion to the piston speed and capacity, the mechanically operated valve and perfect balance make high speed possible without loss in efficiency and economy. This permits of direct connection to electric motors, high speed gas engines or the rotary steam motors manufactured by the same company who make the compressors.

It will be readily appreciated that this design is equally applicable to pneumatic motors and vacuum pumps, both of which are included in this line of apparatus.

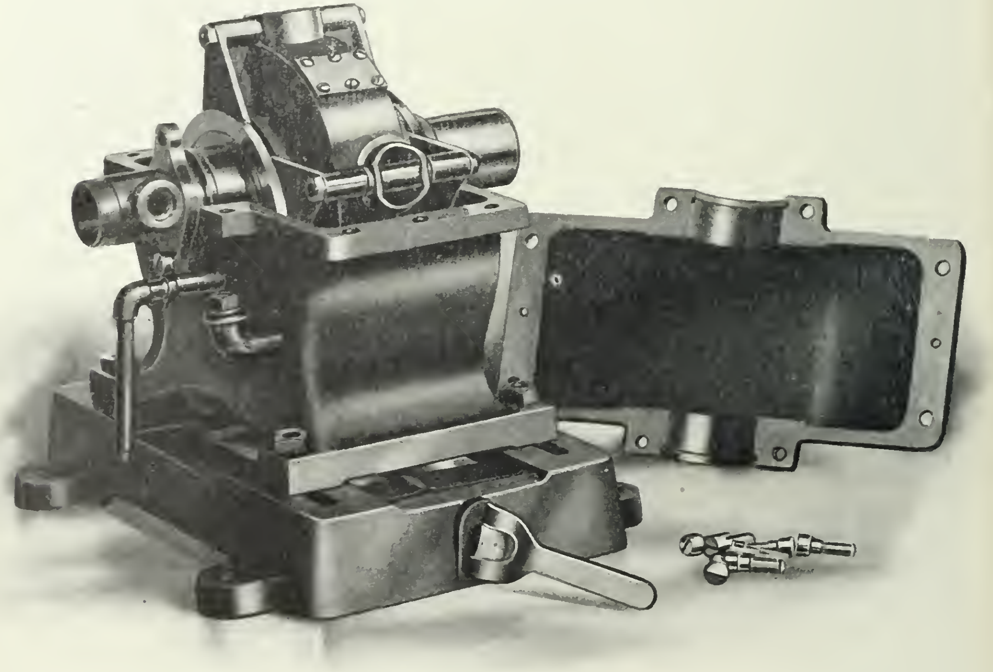
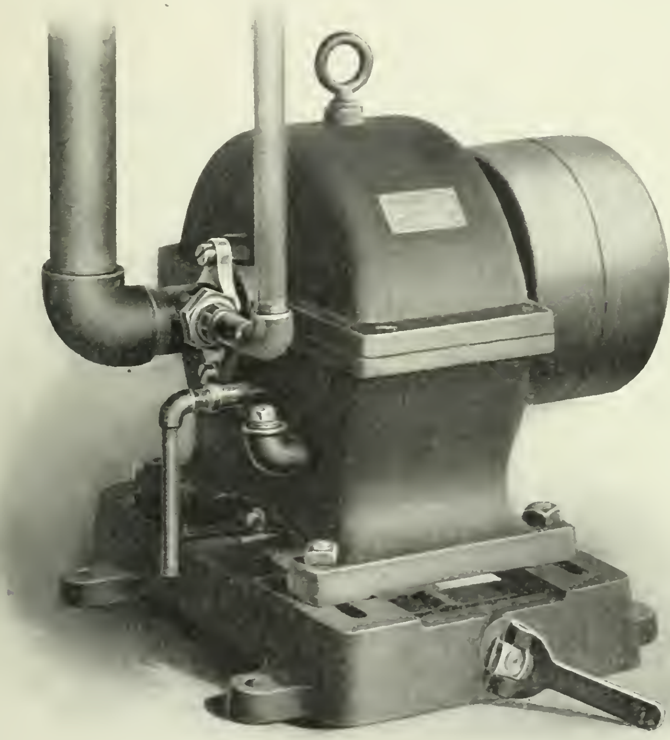


FIG. 2. COMPRESSOR WITH TOP OF CASE REMOVED.

At the present time these machines are manufactured in capacities of from 1 cubic foot of free air per minute to 150 cubic feet. Further information may be obtained regarding their design and construction from the manufacturers, The Roteng Engineering Company, 299 Broadway, New York.

LIQUEFACTION of air is advantageously effected when the air is initially at its critical pressure of about 40 atmospheres, and is cooled by the circulation around it of air which has been cooled by expansion, but to no great extent. An arrangement described by M. G. Claude in *Comptes Rendus* is this: A tube is connected with two liquefiers and an expanding chamber; compressed air is led into this, some going to fill the liquefiers and the remainder passing into the chamber, where it is expanded to fall only to about 160 deg. Cent., passing then round the first liquefier wherein it produces liquefaction at 140 deg., to which temperature it rises itself, then passing on through a second similar expanding chamber, whereby it again falls to 160 deg., afterwards circulating round the second liquefier and acting on it as before, and finally passing away round the inlet tube and so cooling the entering compressed air. By this method 850 c.cm. of liquid air have been obtained per h.p. hour.



BELT DRIVEN COMPRESSOR MOUNTED ON BELT TIGHTENING SUB-BASE.

As a guide to the weights and sizes, the 12 cu. ft. machine weighs 225 lbs. complete with sub-base and runs at 650 r. p. m. The floor space is 17" x 21" and total height to top of eye bolt 22".

COMPRESSED AIR*

Its Production, Transmission and Application

BY LUCIUS I. WIGHTMAN.

If there is truth in the saying that old age commands respect, compressed air certainly has strong claims for respectful consideration, for its past reaches far beyond the beginnings of recorded history. It is not a great stretch of the imagination to picture the primeval savage, in a canoe hewn from a log with a stone axe and shaped with the aid of fire, sailing over the streams and inlets of prehistoric lands under the impulse of the wind caught in a rude sail of skins stretched on a crude wooden framework. But this is a practical age and this is a company of very practical men; and in such a place these imaginary pictures have no place.

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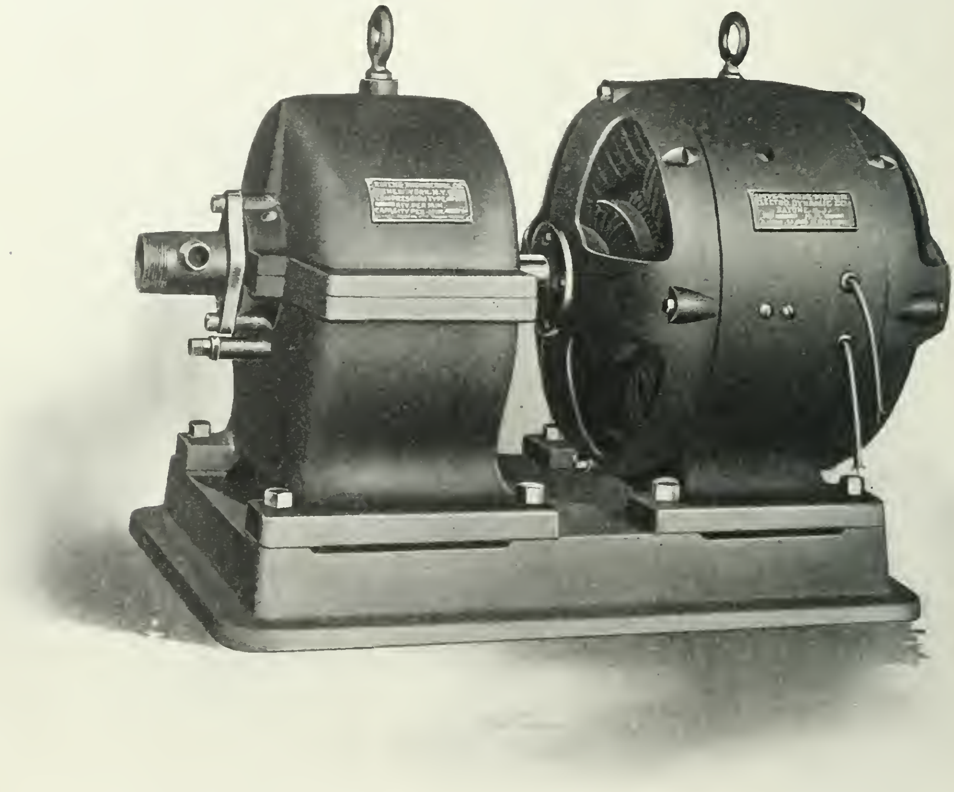
*Abstract of paper read before Engineers Society of Western Pennsylvania.

Coming now to facts, there can be no doubt that air compressed in some degree found practical application in the very earliest ages of man's history. The reduction of metals from their ores was one of the earliest arts acquired by mankind; and the blast furnace must have been the basis of these processes. Just what form these primitive compressors had must be very largely a matter of conjecture. But no doubt their prototypes are found in the appliances still used by savage tribes. Among these may be mentioned the "wind bag" of skin, trodden by the feet, and the wooden box and movable piston, the original of the modern air compressor; and the simple, modest little bellows of the fashionable fireside of to-day is doubtless but little different from those used on the hearths of the most ancient homes.



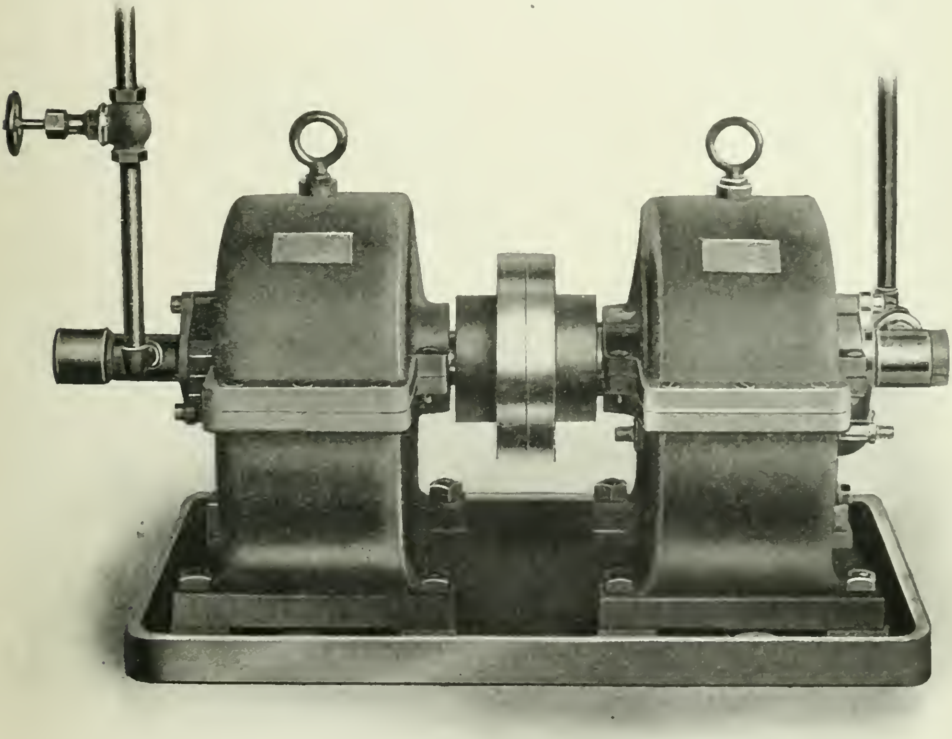
MOTOR DRIVEN ROTENG COMPRESSOR; WATER COOLED; 650 R.P.M.

Heron—or Hero—of Alexandria may perhaps be considered the individual pioneer in air power development. The earliest authentic records of compressed air are found in the "Spiritalia" of this old philosopher. He himself must have had some means, other than the common bellows, for producing the pressures required in operating "Hero's Fountain," which is a feature of all the text books on physics.

The priests of ancient Egypt largely owed their sway over the credulous people to their understanding of the more elementary properties of air. Their supernatural phenomena—so-called—are easily explained to-day by the most simple laws. The miraculous opening of the temple doors when a fire was lighted on the altar was caused simply by the expansion of a volume of air under the heat of the altar fire, this expanded air displacing water from a tank into a suspended bucket, so connected by rollers and cords as to open the doors by its weight. When the fire went out, the doors closed—most supernaturally, to be sure—by a reversal of this process. By the same means did the famous statue of the god Serapis move, on proper occasions. And the awe-inspiring vocal statue of Memnon at Thebes owed its divine voice to the expansion and contraction of an air volume under the heat of morning and the cool of evening.

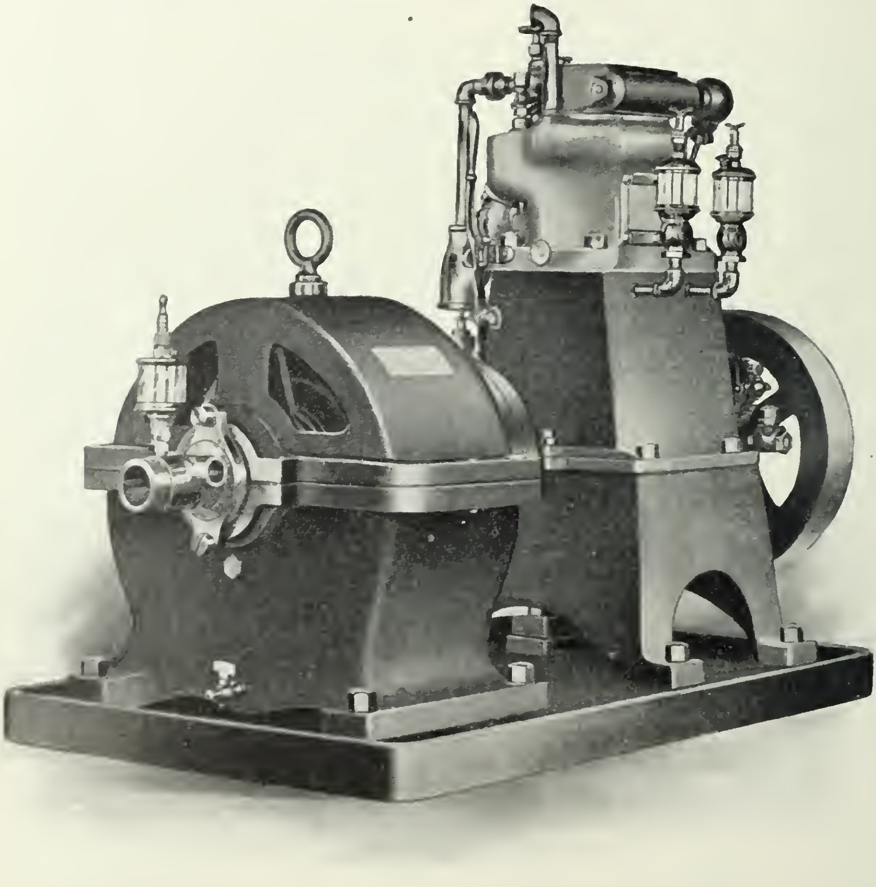
Hero himself—probably the first "hot air" artist—knew of a means of compressing air by the fall of water in a tube—a precursor of the modern hydraulic compressor. Pliny later mentions a similar device. Ctesibius, a famous Alexandrian engineer of about 120 B. C., invented "wind guns" capable of discharging projectiles. To him must be awarded the palm as the first to produce and apply high pressures.

But these are historic curiosities. Passing on rapidly, in the darkness of the early Christian era and of the Middle Ages, compressed air seems to be lost. It reappears again in the writings of Lord Bacon, who describes a diving bell. Then come the records of achievement of Halley, Smeaton and Brunel, in England, and Von Guericke in Germany. Papin, about 1653, devised a compressed air system involving compression in a water-wheel-driven pump and transmission through a tube to a distance. He also experimented with a pneumatic parcel dispatch. His attempts failed through ignorance of the fundamental physical properties of air.



50 CU. FT. PORTABLE STEAM DRIVEN ROTENG COMPRESSOR DIRECT CONNECTED TO ROTENG ENGINE; 550 R.P.M.

The latter part of the eighteenth century and the early part of the nineteenth mark the real birth of air power. During this period Medhurst, the great Danish engineer working in England, laid the foundations of present pneumatic practice. He produced and transmitted pressures of more than 200 lbs., and applied them in motors; he developed a practical, though not economical, system of pneumatic dispatch for parcels and persons; he built the first pneumatic automobile in 1800; and he otherwise contributed richly to pneumatic science. Compressed air as a distinct and recognized branch of engineering may be said to date from this period; and under the mechanical renaissance of this time, developments were rapid. The experiments of this time foreshadow, in diversity and daring, the great achievements of to-day. Pneumatic locomotives and motor cars were built and operated. Pneumatic dispatch systems achieved a practical success in London in 1845. America was not behind the old world; and Dr. Gorrie, of New Orleans, built the first refrigerating plant in 1850 and laid the principles upon which rest the tremendous refrigerating systems of to-day.


GASOLENE ENGINE DRIVEN ROTENG COMPRESSOR; 650 R. P. M.

Mann, in 1829, suggested and patented a system of stage compression with intercooling. But he lost a splendid opportunity to win an immortal name in science by his failure to develop his ideas; they lay dormant for almost half a century. The great Alpine tunnels of the early 70's gave a tremendous impulse to pneumatic development. Sommeiler, on the Mont Cenis bore, used hydraulic compressors. Later developments in this tunnel work brought water piston compressors, with injected jets or sprays for cooling; and pneumatic locomotives were used for haulage in these great bores. The Hoosac tunnel in America first brought the pneumatic rock drill into prominence; and since that time the genius of Burleigh, Ingersoll, Rand, and Sergeant has produced the modern rock drill—probably the greatest single epoch-making device, after the steam engine, in history.

This historical sketch, brief as it is, is convincing proof that compressed air has a legitimate claim to dignity and consideration. It has ceased to be a novelty; it has passed the experimental stage. It is to-day a recognized industrial necessity, firmly established as one of the accepted indispensable factors in modern progress.

Compression, or an increase in the density of a body of air, is invariably accompanied by an increase in temperature. This increase in temperature is wholly independent of the rate or means of compression. It is a phenomenon inherently characteristic of the compression process ,and is the direct result of an increased molecular activity in the air. The temperature attained is a function of the degree of compression; but the factor is not a constant, being largest in the early stages of compression and decreasing as the higher pressures are approached. It is a fundamental law of physics that the production of heat demands an expenditure of power; and the power consumed in producing heat in air compression is lost, so far as the inherent economy of compression is concerned. But in actual practice, this heat might be made use of. In one notable air power plant, the heated water from jackets and intercooler was led to the feed-water heater and in this way there was at least a partial recovery of the lost energy. The degree of heating of jacket water depends largely upon its rate of flow over the heated surfaces; and if any attempt is made to use this heated water for boiler feed, there is a fine problem in determining the exact point beyond which the economy ceases to be a virtue. For in a desire to secure hot jacket water, the efficiency of compression may be sacrificed.

This heat of compression is productive of other evils which can—in degree at least—be obviated; and the efforts of compressor designers have from the very first been directed toward this end. In the path of every pneumatic engineer loom two guide posts; the one points the way to economy, and success—the other marks the path to disappointment and failure. The first is isothermal compression—the second is adiabatic compression.

Isothermal compression is a visionary process in which the heat developed in compression is removed as fast as produced and is, therefore, harmless. It would be a realization of Boyles' law, in the expression of which—$P_1 V_1 = P_2 V_2 = K$ the factor T does not appear. Though the best air compressors of today closely approximate its values, isothermal compression cannot be fully realized, for a perfect cooling system is not known and, so far as can be seen at present, never will be.

Adiabatic compression, on the other hand, is a grim and forbidding reality—a compression process in which all of the heat developed is retained. It represents the two Primary Laws of Gases in combination; and its expression, involving the three variables of pressure, temperature, and volume, is as follows:

$$P_1 V_1 (T_2+459.2)=P_2 V_2 (T_1+459.2).$$

There is a slim consolation to be derived from the fact that adiabatic compression, too, cannot be wholly realized; for no perfect heat insulator is known. But this fact brings more sorrow to the heart of the scientific investigator than to the practical engineer.

Assuming for a moment that it were possible to compress a volume of air isothermally, and remembering that the product of pressure and volume under this condition will remain constant, it is seen that when the original volume has been reduced one half, the pressure attained must, therefore, be twice the original. But practice rudely shatters these theoretical assumptions. For, as a matter of fact, it is found that the pressure is doubled before the volume is reduced one half; and a very decided rise in temperature is noted. Consideration of these facts forces the conclusion that a part of the work of compression was expended in producing the rise in temperature noted; and furthermore, it becomes painfully evident that this heat increment of work is, so far as the compression process is concerned, wholly lost. In other words, when the air during compression is allowed to heat itself, more power is required to produce a given volume at a given pressure than would be necessary if it were possible to keep the air cool throughout the process. In the first case, there would be adiabatic compression; in the second, isothermal compression. This is a very brief, very elementary statement of the phenomena which give rise to the problems which have confronted the designers of the modern air compressor.

It will have been seen from the foregoing brief discussion that the fundamental problems of pneumatic science are thermo-dynamic in character. The production of heat in compression is unavoidable. The solution of these basic problems, therefore, lies in the removal or neutralization of this heat of compression before it can have any effect on the air volume. This cannot be done completely, since no perfect and instantaneous cooling device is known. Scheme after scheme has been tried and found wanting, until to-day two general systems alone survive and are accepted by the designers of compressed air machinery. In combination, they attain the nearest approach to the ideal which, as has been seen, is isothermal compression.

First of these two—by right of seniority if not of effectiveness—stands jacket cooling. The barrels and—in the best air compressors—the heads of the compression cylinders are surrounded by a water space or jacket through which an adequate supply of cold water circulates, the waste water carrying away that portion of the heat of compression which is conducted from the air volume through the metal walls. A possible use of this heated water has already been suggested. Water jacketing is useful, but not adequate. It is useful; first, because it prevents the cumulative effects of the heat of compression which would quickly destroy all lubricants and result in injurious expansion strains in the metal of the machine; second, because it keeps the temperature of the air admission passages and valves low, thus admitting cooler air to the cylinder—and every reduction of 5° in intake temperature is equivalent to an increase of 1% in compression efficiency. Water jacketing is not adequate; first, because air is a poor heat conductor and though the outer film in contact with the cylinder walls is cooled, the heat from the interior of the air volume remains; second, because the advancing piston continually covers up more and more of the cylinder walls and the cool area exposed is continually reduced until, just when the highest temperature is attained at point of discharge, only a small fraction of the total cooling surface is in contact with the compressed air. The jacketing of cylinder heads as well as barrels in the best compressors of to-day improves but does not wholly obviate this defect.

The second accepted system of cooling is that secured by stage compression. In this arrangement, instead of being confined to a single cylinder (or parallel duplex cylinders), the compression process is subdivided between two or more cylinders. In the first and largest, air at atmospheric pressure and temperature is admitted and compressed to a moderate pressure and temperature. This compressed air is discharged into an intercooler where its temperature is reduced, by circulation over and contact with water-cooled surfaces, to almost that of the cooling water—perhaps really lower than atmospheric temperature. From the intercooler, this cool and moderately compressed air enters a second cylinder and is compressed to a higher pressure. In a two-stage compressor, this completes the process; in three and four stage machines, the process is continued in a third, or a third and fourth, cylinder. Correct design so proportions the cylinder diameters that the load on all pistons is equal and the maximum temperatures in all cylinders should under such conditions be approximately the same, since this is a function of the number of compressions and not of the initial pressure.

It may be said in passing that in the early days of pneumatic science a third system of cooling was tried—the injection of water in a spray into the compressing cylinder in front of the piston. It may be interesting to note here that this was one of the first types of compressors built by the Ingersoll Rock Drill Company—one of the originals of what is now the Ingersoll-Rand Company; and some of these old machines are still in use today and doing good work. Their compression economy was as high as, if not higher than, that of the most refined modern types. But they were costly machines. The presence of water in the cylinders enforced a low piston speed and, to secure any great capacity, a machine so large was required as to offer serious objection to their wide adoption. Moreover, the proper regulation of the injection of cooling water under varying loads was a delicate problem. Practical difficulties were found to more than offset their high efficiency, and the type was discarded.

Returning to the question of stage compression, the success of the multi-stage system of air compression depends more upon the efficiency of the intercooler than upon any other one thing. For the primary object of stage compression is the reduction of the power required. There are other advantages which will be mentioned later, but at this point a comparison of the gains by compounding will show strikingly the economical advantage. Assume a volume of 100 cubic feet of free air which is to be compressed to a pressure of 100 lbs. gauge. Were perfect isothermal compression possible, this would require 13.17 horse power to accomplish the work indicated. Average single stage compression, which may be considered as practically adiabatic will call for 18.0 horse power. Two stage compression will demand 15.4 horse power; three stage, 14.6 horse power; and four stage, 14.2 horse power. As compared to isothermal, then, the efficiency of single stage compression in this case is 73.2%; of two stage, 85.5%; of three stage, 90.2%; and of four stage, 92.7%. These are purely theoretical considerations. As a matter of fact, two stage compression should be used in this case. For, while theoretically there is undeniably a higher saving in three and four stages, the added complication of design in the increased number of cylinders, valves and working parts, with complex coolers, might so increase frictional losses as to offset the gain; and it would certainly add to cost of maintenance.

The experience of the best builders of compressors has determined the following limits for pressures in different stages; single stage, up to 100 lbs.; two stage, 75 to 500 lbs.; three stage (straight line), 500 to 2500 lbs.; three stage (duplex), 500 to 1500 lbs.; four stage, 500 to 3000 lbs. The real difference in economy between three and four stage compression is often so small as to make a choice difficult. As a general rule, it may be said that three stage straight line compressors should be used for comparatively small capacities; for moderate and large air capacities, its balanced features and its ready adaptability to steam compounding recommend the duplex type. A three stage duplex will still require four cylinders, hence the process might as well be divided into four stages, with no increase in working parts.

The design of these high pressure machines offers peculiar difficulties. While the temperatures attained are not excessive, the great reduction in volume has made the problem of adequate cooling unusually difficult. But before considering this specific phase of the subject, it will be well to take up the general subject of intercoolers.

The successful intercooler, looked upon simply as a heat-removing element, involves several important considerations. It must provide for a very complete subdivision of the air volume, that internal heat may be dissipated with as little reliance as possible upon the heat-conducting properties of the air itself. It must present an adequate cooling surface to this subdivided air; and it must provide for a circulation of cooling water not only rapid and free, but also properly directed in relation to the flow of air. The first two considerations are met by the same means, viz., by the use of a nest of tubes through which the water flows, and over, about and between which the heated air circulates. Properly disposed baffle plates enforce the travel of the air back and forth across, instead of merely along, these tubes. The air must be outside, not inside, the tubes; otherwise each tube will contain a column of air, only the outer film of which will be cooled, the interior retaining its heat. The third consideration is met by causing the air to flow in the opposite direction to the water. This is found to give higher efficiency and greater rapidity of heat absorption. A fourth consideration ought also to be mentioned, as effecting the thermal efficiency of the intercooler. This is the necessity for ample cross-section in the intercooler passages, that the travel of the air may be slow and the contact with cooling surfaces prolonged. Some modern compressors, while having plenty of cooling surface, have the tubes so closely bunched and the intercooler shell so small that the air velocity in transit destroys the thermal efficiency.

Considerations merely mechanical in the correct design of an intercooler are none the less important. Expansion and contraction must be provided for; otherwise there results either a leakage of air and a proportionate waste of power, or a leakage of water into the air chamber, which may be carried over into the next cylinder. This suggests a very important point, viz., the proper drainage of the intercooler. The lowering of the temperature of the air condenses the entrained moisture. If this is not removed at proper times, it will accumulate over the lower tubes, reducing the cooling area as well as the air passage. But the greatest danger is that this accumulation of water will be caught in the sweep of air and carried over in a mass into the high pressure cylinder; and a broken cylinder head, bent piston rod, or other disaster will result.

Evidently such an intercooler as has just been described, while perfectly suitable for two stage compression, or even three where the air volume is large, is not practical with the small air volumes involved in the later stages of high pressure compression, particularly in machines of small capacity. But long experience and good engineering have solved the problem with success. The method adopted is the complete submersion of the intermediate and high pressure cylinders in water boxes filled with circulating cold water. In this way every inch of metal exposed is a cooling surface; valve caps, air heads, ports, and cylinder walls—all are kept cool, while intercylinder cooling is secured by novel devices. It will be enough to describe one which experience and careful test have shown to be most effective and efficient—the "annular space" intercooler. It consists of two concentric metal cylinders, as thin as the pressure will permit. Their difference in diameter is such as to leave a thin annular space between them, through which the heated air from the intermediate cylinder must pass, spreading out in a thin film between two cold metal walls. The coldest entering water is discharged in the interior of the inner cylinder, and flows thence into the water box in which the intercooler, as well as the compression cylinders, is immersed. The discharge pipe from the intermediate cylinder to the intercooler is entirely submerged, itself acting in some degree as a cooler.

High pressure compressors are no longer "freak" machines, unreliable and largely experimental. The increasing use of high pressure air has demanded a solution, once for all, of the problems of high pressure compression; and the pneumatic engineer has been equal to the task. The best thousand pound pressure compressors of to-day are as reliable, as efficient, as thoroughly "standard," as the lower pressure machines.

It was mentioned earlier in this paper that there were other advantages than increased economy to be gained by compound or stage compression. They are well worthy of consideration in their effect upon ultimate economy and will be briefly discussed here.

The mechanical structure of a machine must be adequate to the maximum strain upon it. This predetermines the minimum amount of material in it. But the endurance of that machine depends upon its factor of safety; and good design demands that this be kept large, with the minimum amount of metal used. In other words, while the maximum strain must be provided for, the average strain must be kept well below the maximum, if the machine is to operate well under long and continuous service. Compound air compression reduces the structural strains in the compressor, resulting in a higher factor of safety and longer life for the machine, with a given weight of metal. In a single stage compressor, the piston starts against no resistance but rapidly builds up a pressure to terminal maximum; and this is maintained until it is instantly relieved by the opening of the intake valves. A 24-inch piston compressing to 100 lbs. gage, single stage, encounters a total resistance of 45,239 lbs. or nearly 23 tons; and at 90 r. p. m. this is encountered and relieved 180 times each minute. It will take the best of metal and plenty of it to stand up under such service as this. But let this same work be done in two stages. The maximum pressure on the low pressure piston will depend upon the cylinder ratios. The pressures in the high and low pressure cylinders will, moreover, partially balance and equalize; and it is found that as a matter of fact, the maximum strain in the machine is reduced to only 55 or 60 per cent of the maximum in single stage compression—in the example cited, from 4140 "ton minutes" to 2277 or 2484 "ton minutes." These are impressive figures and suggest almost unlimited possibilities in the way of improved operation and longer life. This difference in pressures is felt not only in the machine structure, but also in the valves, which must always be considered the most vulnerable, as well as most vital, detail of the compressor. But—and here is a vital point too often overlooked by the designer—this maximum strain of 4140 ton minutes must still be provided for in the machine structure. For the momentary failure of cooling water supply, or the breaking of a high pressure discharge valve may at any moment throw this full high pressure load on the low pressure cylinder. When this happens in a compressor designed only for compound strains, there is nothing to be done but sit down and figure the damages. The engineer or manager contemplating the purchase of a compound compressor will do well, when it comes to a comparison of prices, to figure the comparative costs per unit weight; and, other things being equal, he should give his order to the builder of the heavier machine, whose price, figured on this basis, will not seem so unreasonablly high. But there are, unfortunately, builders who, alive to this fact, give list weights on their machines higher than strict honesty would permit; and the only safety for the buyer is in the insertion of a penalty clause in his contract, based on the actual net weight of the compressor. This will protect him against over-enthusiastic and imaginative manufacturers.

Another advantage of compound compression lies in the improved steam economy if the machine is steam driven. The conditions just cited in the previous paragraph explain this. It was seen that the terminal strain on the machine, and therefore the terminal power required, was reduced by compounding 55 to 60 per cent. Manifestly this permits a lower mean effective pressure in the steam cylinder, secured by a shorter cut-off, since the power required at the end of the stroke is so much reduced. More of the work of "passing center" may be entrusted to the energy of the flywheel, instead of being provided for by a late cut-off. The mechanical features already mentioned permit also a higher piston speed, improving the steam economy by reducing leakage and condensation losses.

Compounding the compressor also has an important bearing on the volumetric efficiency of the machine—a fact which is due to three causes. As effecting volumetric efficiency, the clearance in only the low pressure or intake cylinder need be considered. In the single stage machine, clearance air at end of stroke may be at a pressure three or four times that which exists in the intake cylinder clearance of a compound compressing to the same pressure; and on expansion it will occupy a proportionally larger portion of the cylinder, before free air can enter. Further than this, the terminal temperature is lower in the compound intake cylinder than in the single stage. Cylinder heads and walls, valves and ports are thus kept cooler, and the incoming air is not so much heated. Further, leakage past pistons and valves is less in the compound than in the simple machine, since the difference in pressure is less.

At this point a slight digression may be permitted. The indicator diagram of an air cylinder is a reasonably accurate record of pressures; but it is wrong to base any estimate of volumetric capacity upon the air card. When the inlet valves open, air rushes into the cylinder and fills it. If the air enters through heated ports, it is itself heated and expanded—and the volumetric capacity of the compressor is accordingly reduced. There is too pronounced a tendency toward valuing a compressor by the card it shows. This is but one of the ways in which an apparently excellent card may in reality hide a true state of affairs directly opposed to high economy.

It may be almost unnecessary to suggest the advantage of compounding in its relation to improved lubrication and, to this extent, in its effect upon the life and operation of the compressor. The terminal temperature in a cylinder being a function of the number of compressions in that cylinder, the high temperatures of single stage compression may result in the charring of the lubricant into a gritty or gummy substance which, accumulating in valves anl passages and on cylinder walls, results in excessive friction, added power and lowered efficiency by leakage.

Still another gain by stage compression is in the dryer air delivered by the compound machine. It developed in the discussion of the intercooler, that that device, properly designed and drained, was an effective dryer and moisture trap. But it is only one link in the system of withdrawing water entrained in the air. The importance of removing the moisture from compressed air is becoming more generally appreciated under the present tendency toward larger units, and longer and more complex air transmissions. In long pipe lines carrying large volumes of air, moisture, if present, will accumulate in the low places in the line and will ultimately fill the pipe, shutting off the passage until the air pressure forces the water up and overcomes the resistance. The writer, in going over the pipe line of a large contract plant in Pennsylvania, was attracted by a periodical rush of water through the 8-inch pipe. Following the line to the next low place, he found a 1-inch drain pipe. Opening this, it took eight minutes by the watch to draw off the accumulated water, which had been rushing up and flowing back repeatedly. Yet he was assured by the foreman that that place had been drained less than two hours before. The plant in question was made up of single stage compressors, with no coolers whatever. Aftercoolers would have prevented this trouble.

Now, this illustrates a point of vital importance in its bearing upon transmission line efficiency. Going further, to the machine using the air, it is unnecessary to dwell upon the trouble and delay caused by the freezing up of exhaust ports, due directly to the presence of moisture in the air. Occasionally the builders of compressed air machinery meet a situation which forces them to the belief that the real cause of freezing at drills and air motors is not fully appreciated. There is often a mistaken idea that it is the atmospheric termperature which causes this. On the contrary, the writer has seen rock drills freeze tight at midday in the torrid August sun of central New Mexico. The fact of the matter is that the cold is produced directly by the expansion of the exhaust air. It was seen that the compression of air, by a molecular action, produces heat. The exact reversal of this molecular action, in expansion, produces cold. Naturally the trouble is exaggerated in winter weather. But if the moisture is removed from the air before expansion, no air motor can freeze up however high the degree of expansion. for the very simple reason that there is nothing to freeze. In a great quarry plant of northern Ohio, rock drills are operated in the open air with the thermometer far below zero, with not even a suggestion of vapor at the exhaust. But the compressor intercooler is not wholly adequate to this problem of air drying. At best it can remove only a part of the moisture in the air. There must be some further arrangement for air drying; and this leads naturally to a discussion of aftercoolers.

The aftercooler is in essentials identical with the intercooler. Its efficiency is determined by the same conditions; in fact, in compressors of duplex type. the intercooler and aftercooler may be identical in design and capacity. Aside from removing the evils of water in the transmission line, with increased frictional resistance and liability to freeze up in winter; and aside also from avoiding the trouble with "frozen" air motors, the use of an aftercooler is important in its effect upon the life and operation of the motors themselves. Water is not a good lubricant; equally axiomatic is the fact that oil and water will not mingle. The actual fact is that the delivery of water to a drill or other air motor washes out the lubricant, increasing the wear and reducing its effectiveness. Especially true is this in the case of pneumatic tools. where a light lubricant is used. The use of moist air in an expansive engine is practically impossible—a fact largely responsible for the ill-repute of the air motor. Complete aftercooling makes this possible in many cases.

Of value no less important in the air power system is the effect of aftercoolers upon the transmission line efficiency. Nothing will destroy air plant efficiency more quickly and effectively than a leaky pipe line; and nothing is so conducive to a leaky line as wide extremes of temperature, with consequent large strains of expansion and contraction. Without an aftercooler, air from the compressor enters the pipe line hot; the line itself is cold. There is an immediate expansion which extends along the line with continued operation. Now, when the air plant is shut down—probably at night—there is a corresponding contraction all along the line. There needs no voice from the tomb—or elsewhere—to dilate upon the resultant difficulty in keeping tight joints and preventing leakage, even with the best mechanical precautions in the line. The aftercooler is not a luxury; it is an economical necessity in the high-grade air power plant.

The Cleveland Stone Company, at their quarry at North Amherst, Ohio, have an air power plant which is probably without a peer as an example of refined pneumatic engineering. The transmission lines in this system aggregate miles in length and the power is used in drills, channelers, pumps, hoists, mill engines and steam shovels. While reheating is now employed on all but the drills, it was not originally used; yet the engines were for some time worked on short cut-off, and in the midst of a cold winter no trouble was experienced with freezing of lines or motors. The remarkable result is explained by the exceptional precautions taken to provide dry air; and a brief description of the methods employed may not be out of place here.

In the first place, the air enters the compressors through "air washers," which enforce its passage downward through tubes and then upward in bubbles through a body of cold water. This removes from the air the all-pervading dust and grit of the quarry, and incidentally dries it somewhat by lowering its temperature and condensing some of the moisture. Leaving the low pressure cylinder, the air passes through an intercooler, thence to the high pressure cylinder and thence to an aftercooler. From this it goes to very large primary receivers from which the transmission lines radiate; and at intervals along the lines are secondary receivers set *below* the pipe grade. Moisture is first withdrawn from the air in the "washer;" and then in turn in the intercooler, the aftercooler, the primary receivers, and the secondary receivers. The result is the delivery of absolutely dry air to the motors and maximum pipe line efficiency under all weather conditions, though the lines and the machines are all out-of-doors and unprotected.

More remarkable still, the miles and miles of pipe line have not a single leak. On the contrary, they hold working pressure over night; they were installed under a guarantee to hold full pressure for twenty-four hours. Much of this, of course, is attributable to fine workmanship and studied design, But more than these is it due to the uniform temperature maintained by the use of efficient aftercoolers, with consequent freedom from excessive expansion and contraction strains.

Coming now to consideration of the mechanical design of air compressors, it is found that accepted practice divides these machines into two great fundamental classes—straight line and duplex. The changes which can be rung on variations of these two designs are almost infinite. But analysis will reveal a difference only in detail. The basic principles upon which the designs rest are the same in all.

The straight line air compressor may be considered the pioneer type. The term "straight line" is one of the happy expressions, of mechanical phraseology, for it carries with it its own explanation. Its fundamental and distinguishing characteristic is the fact that power is directly applied to resistance. This at once implies simplicity, lack of complication, absence of many parts with undue power consumed in friction. All this results in a machine of high mechanical efficiency and reliability under continued hard service. Its simple design renders it especially attractive for conditions which afford only unskilled attendance. There can be no more sturdy and dependable compressor than the good modern straight line. The compressors examined in the tests reported above belonged to this class; and the figures there set forth show that this type leaves little to be gained in volumetric efficiency. This is a condition, moreover, which is practically constant at all speeds. The main difficulty with the straight line compressor develops in the steam end.

Variable cut-off steam valves give good steam economy at or near normal speed. But the inherent characteristic of the design—the direct opposition of power and resistance—produces conditions which offer serious objections to the straight line machine under widely varying load. In the cylinders, steam pressure falls as air pressure rises; and the flywheels must be relied upon wholly to carry the machine over dead center. This is all very well at high speeds; but reduced load calls for a reduced speed, else there will be a total waste of power by the escape of air at the relief valve. At low speed the energy in the flywheels is not sufficient to pass the center, if the cut-off is short. Cut-off cannot be automatically varied with load, as in a Corliss machine; and to avoid entire stoppage on light load, either the cut-off must be lengthened to give sufficient power to pass centers, in which case there is a waste of steam when the machine speeds up under returning load, or there must be a fixed point below which speed must not fall, in which case there is a blow-off of compressed air at all loads below this limit. These facts force the somewhat unpleasant conclusion that the straight line compressor is not economically self-regulating at less than 35 or 40 per cent. of full load.

This condition practically forbids the successful compounding of the steam end of a straight line. For the high expansion, which is the secret of compound economy, only exaggerates the difficulties at fractional loads. The "double-compound" straight line compressor is practically a constant-speed machine, its economical cut-off admitting of no variation. At normal speed it gives good economy; but underloaded the waste of air at the relief valve simply offsets its normal advantage.

But the straight line compressor is not to be wholly condemned. It remains to-day—and justly so—the most popular machine for plants of moderate capacities using moderate steam and air pressures and working under fairly constant loads. These are the very conditions characterizing the majority of cases in which compressed air is used; and they are conditions in which high steam economy is less important than moderate cost and thoroughgoing reliability.

The second great class of air compressors is that broadly designated as the duplex type. This is not the place for a minute investigation of structural strains and theoretical considerations. For the present purpose it will perhaps be best to look at the duplex compressor as simply two straight line machines set side by side and coupled up for mutual assistance. Seen in this light, the duplex is found to possess all the advantages of the straight line, with the addition of some very important superiorities distinctly its own.

The first of these superiorities lies in the matter of regulation. Quartered cranks permit one steam cylinder to help the other when it most needs assistance; and, a quarter of a revolution later, this favor is reciprocated. The arrangement admits of no "dead center;" and a good duplex will run so slowly at highest loads as to barely turn over, speeding up instantly, however, with increasing load. Best of all, it does this without any change of cut-off; and whether the speed be high or low, steam is always used economically.

But it is as a "double-compound" compressor that the duplex stands without a peer; for in all probability high steam expansion in compound steam cylinders will effect a saving three or four times that secured in stage compression. In the first place, either steam or air end can be compounded without any increase in the number of parts. More than this, the reciprocal cylinder arrangement secures the full advantage of compounding *over the entire load range.* The fact—peculiar to air compressors—that the load per stroke is constant regardless of speed makes a "double-compound" air compressor as completely self-regulating as a simple machine. There will be a slightly increased condensation at lower piston speeds; but the fact that friction loss is a function of the speed and diminishes with it, introduces a saving about offsetting the increased condensation loss at low speed. For these reasons the steam consumption of a double-compound duplex is very nearly proportional to its load.

As compressed air enters more and more largely into industrial activities, the size of plants and units increases, and the demand for economy grows more imperative. It is this condition of affairs which is bringing the duplex compressor into ever-increasing prominence and popularity. It is recognized as distinctly the machine for high grade permanent plants of moderate or large size, using modern high steam and air pressures, operating under widely varying loads and under conditions which make economy of fuel and water essential.

An extended discussion of the subject of air compressor valves is out of the question in such a paper as this. Volumes could be written upon it. It will be enough here to briefly review the essentials of a correct air valve. It may be safely left to the intelligence of the audience to draw just and adequate conclusions as to the merits of any particular valve they may have in mind.

The air intake valve will logically receive attention first. Briefly, its functions are, to admit the full volume of clean, cold air to the cylinder with the least expenditure of power; to keep this air in; and to maintain this performance indefinitely. Analysis of this general statement will develop the facts sought. First, the valve must admit the full volume of air; this demands an instantaneous and complete opening, automatically timed to prevent the escape of air already compressed, and short, direct and unobstructed ports and passages. Second, it must admit clean air, calling for a design which will admit of connection for drawing the air from a place free from dust and grit. Third, the air admitted must be cold; this is partially met by the arrangement necessitated by the second consideration; but more than this, the cold air must nowhere be heated in transit, demanding valves, ports and passages cooled by the jacket water and never called upon for the discharge of the hot compressed air. Fourth, all this must be accomplished with the least possible expenditure of power—a condition demanding few parts and perfect adjustment. Fifth, this valve must keep the air in, calling for automatic and complete closing at just the right time, with perfect seating to avoid leakage. Sixth, it must maintai this performance indefinitely, hundreds of times per minute, demanding simplicity and strength, fine workmanship, and the very best materials.

Similarly, the functions of the air discharge valve are, to release the full volume of compressed air from the cylinder with the least expenditure of power; to keep it out; and to sustain this service indefinitely. This statement also may be analyzed for the essential facts. First, the release of the full air volume calls for automatic timing of an instantaneous and complete opening, and full, free, direct discharge passages. Second, this must be performed at the least cost for power, necessitating few parts and proper adjustment, that friction may be low. Third, the valve must keep out the air it discharged, which means that it must close instantaneously and completely to a perfect seat at just the right time. Fourth, the continued maintenance of this performance demands simplicity of design, strength of parts, materials of the best quality, and fine workmanship.

It will be noted that the essentials of the successful intake and discharge valve are practically identical, the only difference lying in the necessity for admission of *cold* air through the former. This fact forbids the admission and discharge of air through the same passages. Furthermore it demands that intake and discharge passages shall be separated as far as possible.

It is unnecessary to enter into any extended investigation of the steam end of the steam-driven air compressor. The best engine practice is, broadly speaking, the best compressor practice. But there are conditions in air compression which, in relation to compounding the steam end, seem often not to be well understood.

When steam cylinders are to be compounded it is essential, in order to attain full advantage of expansion, that the cut-off be maintained almost constant at the point fixed by the ratio of the cylinders; for any great change in the cut-off will derange the expansion ratio and prevent the economy sought. Now, in customary engine practice which demands a constant speed, load variations are met by shifting the cut-off; and with light loads the condensation loss due to excessive expansion will make the net saving by compounding questionable, to say the least. Especially is this true where the engine runs non-condensing, and for this reason small and medium sized engines are seldom compounded. But in a correctly designed air compressor of duplex type, governing is done in just the reverse manner, viz., by maintaining a fixed cut-off at point of highest economy and varying the speed automatically with the load. The reasons, therefore, which usually decide against compounding (particularly in small and medium-sized plants) where the steam pressure is low or condensing is not practicable, do not hold with air compressors.

When a new plant is to be installed, including boilers, these can be made for 125 lbs. steam pressure at very little added cost; and this is a very good pressure for compounding. But that peculiar condition of air compression just described, viz., *constant load per stroke regardless of speed*, makes compounding advantageous and economical, all things considered, with boiler pressures as low as 90 lbs. non-condensing, or 75 lbs. condensing. Where boiler water is scarce or costly, or of a bad quality, the reduced amount of feed water required may be added argument in favor of compounding. While where new boilers are to be installed, the smaller boiler equipment permitted by this reduced steam consumption will partly offset the small added cost of the "double-compound" compressor. Cut-off of one half in compound cylinders will give the same expansion as cut-off of one quarter in a non-compound; and it is easy to see that this fact gives to the compound advantages wholly in addition to mere economic gains, in the reduced load on valves and valve mechanism, reduced leakage, diminished clearance evils, lowered condensation losses, improved lubrication, and diminished wear and tear.

In all this it is to be remembered that compressor practise is unique in that while the speed varies with the load, the load per stroke remains constant at all speeds. Power, therefore, remains constant per stroke, and all the advantages outlined above are fixed in their values regardless of load.

The regulation of steam driven compressors need not be discussed here. The methods employed are too well known. But the principle, whatever the device employed, is the same in all—a variation of speed to change the displacement to meet varying demands for air. But when some other power than steam is the prime mover of the compressor, other means of governing must be used. And this leads naturally to the subject of power driven air compressors.

The power driven air compressor is essentially a constant-speed machine. Since its actual piston speed and therefore displacement cannot be changed, the only means of adjusting the volume of air compressed to the demand lies in making ineffective a portion of the displacement. But evidently economy forbids blowing off superfluous air through the relief valve. There are three general methods of "unloading" a compressor. One is by opening, at light loads, a passage from the intercooler to the atmosphere, discharging the low-pressure air until load is resumed. This is simply a waste of power—yet better than blowing off high pressure air. Another method is by automatically holding open one or more discharge valves at both ends of the air cylinder, which balances pressures on both sides of the piston and removes all but the friction load. This is a very complete and positive unloader—and therein is its only objection. If the unloaded piston is traveling under balanced pressure of 100 lbs. on each side, and load is resumed at any point of the stroke, on the return stroke the piston must displace a full cylinder of air at 100 lbs.; in other words, the load during this return stroke is three or four times the normal maximum. This overload, moreover, is instantly thrown on the piston, held throughout a stroke, and is instantly relieved; and this sudden, positive assumption and release throws strains on the machine structure which limit the use of an unloader of this type to compressors of comparatively small capacity. The third method of regulation is by limiting or varying the compressor intake—and this comes very near being a solution of the problem. Receiver pressure controls a valve in the free air intake, throttling it when load is light, opening it as load increases. An oil damping device makes the unloading and loading gradual and perfectly safe in all capacities. But this device is not without its draw-back. As the intake is throttled, the air admitted to the cylinder becomes rarified, and on return stroke, though the free air volume is small, the range of pressures is so much increased that terminal temperatures may soar to destructive heights. This style of unloader, therefore, is not wholly adequate where the load variation is very great; and the difficulty increases with the terminal pressure.

In the regulation of the power driven air compressor plant, less reliance must be placed upon the automatic regulation of the individual machine than upon the intelligent sub-division and management of the plant itself. The old-time truism about the folly of putting all the eggs in one basket has become so polished by use that it is to-day really a gem, nowhere more apropos than in the modern pneumatic power plant with power driven units. At the outset it must be remembered that the power driven compressor has no overload capacity, *i. e.*, an overload of volumetric capacity or piston displacement. In the installation of a plant made up of these units, therefore, the maximum capacity must be provided for in the normal output of the machines. Yet fractional loads must also be provided for; and here the designer is confronted with another inexorable condition, viz., the power driven compressor unit is a constant-speed machine.

It may be remarked here that in 90% of the installation of power driven compressors, either electricity or water power will be the prime mover; and of these, probably 80% will be electric driven and the remainder water driven. It will be safe to consider the case of the electrical compressor as typical, since the deductions will apply almost equally well to those driven by water motors.

The electric motor has its maximum efficiency under continuous running at its full load rating. Below that, efficiency falls away. Plant economy, therefore, forbids underloading the electrical compressor unit to any great extent. But in all probability the load curve of the plant will vary widely. Since the individual unit cannot be relied upon for economical regulation, the only solution of the problem lies in the sub-division of the plant into units, of suitable capacities to be determined by the character of the load. This subdivision should be such that the greater variations could be provided for by cutting out one or two or more units, the others meanwhile continuing to run at or near full load. A theoretical case may best illustrate the principle.

Assume that the problem is to install an electrical air power plant which is to work under load variations of from 500 horse power maximum to 75 horse power minimum, with a normal of 400 horse power. The proper solution, in order to get the best economy possible, would be the installation of three motor-driven compressor units; two of 200 horse power and one of 100 horse power. The smaller unit would have an automatic unloader, preferably of the third type mentioned. The possible combinations of this plant would be 100, 200, 300, 400 and 500 horse power, under all of which the motors and compressors would be running at maximum efficiency. When the load fell below 100 horse power the unloader would safely and economically care for a reduction of 25 or 30%. Such a plant could be made very largely automatic by the use of automatic relay starting-and-stopping controllers, in which the governing valves are adjusted to work in proper rotation under slightly different variations of pressure.

This in briefest outline is the system of unit plant design. It requires an intelligent adjustment of operating conditions to smooth out the load curve as far as possible. But it offers a full solution of the problem of economical management of a large power driven compressor plant under varying load. This is a point at which electrical and pneumatic practice meet, and the difficulties involved are well worthy of the best talent in both lines of engineering.

The gas engine driven air compressor is to-day largely an unknown quantity. In small units, for portable work or other purposes requiring only small capacity, it has been successfully built and operated. But in larger sizes it is still largely in the experimental stage. The problems involved seem not to be beyond solution, and they are already well understood. But there has not been enough demand for this class of machines to develop an experience which can be safely relied upon. If, as is sometimes said, the gas engine is the prime mover of the future, it behooves the pneumatic engineer to face the problems of gas engine compression. But as yet the occasion has not arisen; and pneumatic engineers to-day find quite enough to occupy their attention in other lines.

The second of the three general divisions adopted in this paper comes now for discussion.

The phenomena of air expansion are governed by the same laws as those of air compression. Boyle's and Gay-Lussac's Laws of thermo-dynamics express the relations of pressure, temperature and volume. In fact, the theory of the application of compressed air may be best understood by considering expansion simply as a negative compression process. Isothermal expansion is expansion at constant temperature, *i. e.*, no heat is lost. It is an impossible ideal, whose value can at best be only approximated. Adiabatic expansion is expansion with a total proportionate loss of heat; and it, too, can be only partially realized.

Were isothermal expansion possible, the expansion of a given quantity of air to one half its original pressure would give a volume just twice as large as the original. As a matter of fact, in practice the volume will not be doubled when the pressure is reduced one half. For the expansion, reversing the molecular action of compression, results in a lowered temperature which contracts the air volume , according to Gay-Lussac's Law.

As, in adiabatic compression, there is a loss as compared to isothermal due to the *positive* heat increment of work, so, in adriabatic expansion, there is a loss as compared to isothermal due to the *negative* heat increment of work. There is, therefore, in adiabatic compression and expansion a double loss of energy. It was shown that the loss in compression can be reduced, but not wholly avoided, by removing the heat of compression as fast as produced. So, in air expansion, the loss may be diminished, but not obivated, by "removing the cold," *i. e.*, by heating the air during expansion. With this elementary theoretical sketch, the subject of reheating may be taken up.

Evidently it is impossible to heat the air in an expansive engine *during* expansion. But the same effect may be secured by heating the air before it enters the cylinder, thus giving it an excess initial pressure such that the expanded volume will be normal and at normal pressure. If heating is carried only to this extent there is no positive gain, but simply an avoidance of an otherwise inevitable loss. But this is by no means the limit of the possibilities of reheating.

Gay-Lussac's Law states that, at a given pressure, the volume is proportional to the temperature; which means that reheating is equivalent to an increase of volume at that pressure. Or, looked at from another viewpoint, reheating a given volume of air will increase its pressure. In either case, reheating results in a positive increase in the available energy of the compressed air.

With single cylinder or duplex air engines, preheating only is practicable; and it results in securing the same mean effective pressure in the cylinder with a greater degree of expansion and therefore with a greater economy of air. But compound air engines, such as may be used on pumps or hoists, permit both preheating and interheating. This is "stage expansion" and is the exact reversal of "stage compression."

The limit to which reheating may be carried seems to be fixed only by the endurance of the materials exposed to the high temperatures; more especially, by that of the lubricant used in the engine cylinders. But where an oil of high flashing-point is used, the temperatures which may be applied are surprising; for while the initial temperature may be very high, the wide range of expansion results in a mean cylinder temperature which is within reasonable limits and wholly practicable.

The reheating of compressed air offers the most inviting field for pneumatic research today; and it is a field which is only beginning to be explored. Facts and figures are singularly hard to get hold of. While many types of reheaters are on the market, the wide variation in capacity ratings shows that even the builders are not at all certain of their ground. But there is an awakening in progress. All other pneumatic appliances are nearing the limit of mechanical and economical refinement. Compressed air is reaching out beyond the small mine or shop plant into the vast field of general power transmission on a large scale. The rock drill and pneumatic tool do not use air expansively, nor is their mere air economy a fair measure of their value. But for pumping, hoisting and general industrial use as a motive power, in units of any capacity, expansion must be employed if any degree of economy is sought. The great companies who are to-day the leading exponents of air power are alive to the requirements of the situation. Their engineers are grappling with the problems of reheating with the same skill and energy which have been brought to bear along other lines of pneumatic development. When compressed air reaches a condition of advancement where the very highest economy of application is essential, the builders of air power machinery will be ready with reheaters of the same reliability and efficiency which mark the other pneumatic appliances of to-day, placing them in a class distinct and unique among the mechanical developments of the past hundred years.

It was suggested to the writer that in this paper there be embodied a comparison of compressed air and electric power. But an evening could be devoted to that subject alone without doing it justice. It may be said, however, in closing, that the rivalry between compressed air and electricity is more imaginary than real. A few years ago, perhaps, each viewed the other with suspicion. But in this age of tremendous industrial development and inexorable sifting-out of non-essentials, all things worthy of survival find their proper place. It has been so with compressed air and electricity. Each has a field distinctly its own, into which the other can not hope to enter with any prospect of success. At points these fields touch or even overlap; but even here, instead of bitter rivalry, there is a mutual recognition and a cordial co-operation.

When compressed air and electricity *do* join forces, the result is apt to be spectacular, from an engineering standpoint. Where can be found a greater masterpiece than the electro-pneumatic switch and signal system of the New York Rapid Transit Subway, in which the electric current throws the valve admitting the sturdy power of compressed air from automatic air compressors driven by electric motors? Or what can be more striking, more simple or more absolutely dependable than the storage air brake system of the St. Louis Transit Company, in which the air from automatic electrical compressors controls the electric cars which carried the hundreds of thousands of World's Fair passengers without a mishap, a break-down, or a delay? A hundred other instances might be cited in which air and electricity—either powerless without the other—have joined hands in a wonder-working achievement; and nothing can prove, better than these great co-operative triumphs, that the days of competitive strife between compressed air and electric power have permanently passed.

AIR MAINS

Pipes supplying air to rock-drills should be of a size to permit the passage of air at a velocity not greater than 25 to 30 ft. per sec., while all bends and angles (especially short ones) should be avoided, as they add greatly to the friction of the air, and thus decrease the pressure. The friction of the air is proportional directly to the length of the pipe, and to the square of its velocity. For this service, pipes up to 5 in. diameter are provided with couplings, above that with flanged joints made up with gaskets. Great care must be taken that these joints are perfectly tight, as the loss, even from a pin-hole, is considerable.

JAMES CLAYTON

Fifty-seven years ago James Clayton came to this country from his birthplace, Homer, in Shropshire county, England, and became interested in the gold fields of Grass Valley, California.

Between the years of 1864 and 1867 he started in business manufacturing air compressors and pumps.

Always keenly alive to the development of the business which he had founded, he still found time to pursue and successfully complete a number of valuable inventions, such as compressors with mechanically operated valves, an efficient fire pump, the first one having been built for the Long Island Railroad grain elevators, and improvements to a system for pumping water by means of the air lift.

It is interesting to note that among the first compressors built and sold by Mr. Clayton to such concerns as the Copper Queen Mining Co., Plymouth Coal Co., Jamaica Government Railways, and the Highland Mary gold mine, was a machine built for a Dr. Sass to be used in connection with a pulmonary cure.

At the age of eighty-four he is still enjoying a full measure of health, and the photograph which we are privileged to reproduce will doubtless bring back many reminiscences to a number of our readers who are proud to call themselves his friends.

JAMES CLAYTON.

IT is suggested by a trans-Atlantic contemporary that air brakes be used on motor 'buses. It goes on to say that compressed air would also be very useful for other purposes, such as increasing the volume of the gas sucked in on the induction stroke, blowing the horn, and starting the engine.

COMPRESSED AIR
Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., . Managing Editor
P. F. KOBBÉ, JR., . . Business Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. DECEMBER, 1906. No. 10.

AIR BRAKES FOR MOTOR CARS

A comparatively new field for compressed air is suggested in an article by Mr. Thomas J. Fay in a recent issue of the *Horseless Age.*

Mr. Fay points out that most automobile accidents are due to one of the three following causes: 1. Lack of judgment of the distance in which a motor car may be stopped. 2. Rupture or deformation of some essential part of the car. 3. Lack of efficient brakes, or brakes out of adjustment. Of these three possible causes the latter undoubtedly is responsible for a considerable portion of the accidents on record.

Air brakes for automobiles may be divided into two distinct types, according to whether they are operated by air pressure or are applied by a spring and released by air pressure. The latter type, therefore, should more properly be termed "air released" brakes and possess the advantage over the former type that, if out of order, the brake would be applied and the car could not be started.

Mr. Fay states that the dimensions of brake cylinders for the heavier type of cars with ample weight on the traction wheels (to which the brake should be applied), should be approximately as given in the following table:

6.000 pounds	5	in. diam.	x 12 in. long
5,000 "	..........4½	" "	x 12 " "
4,000 "	4	" "	x 12 " "
3.000 "	..........3½	" "	x 12 " "
2.000 "	3	" "	x 12 " "

It is pointed out that it is not necessary to use an air compressor for operating air brakes as the pressure can be obtained from the motor cylinders. This is an important point, as one of the chief arguments against air brakes for use on motor cars has been that the air compressor absorbed a great deal of power; in fact, it has been estimated that the power required to operate the air brakes of a motor car would be approximately one-tenth of the power of the engine which, in the case cited, amounted to 3½ H. P.

It is evident that by using the pressure to be obtained from the motor cylinders the above objection is obviated and the use of air brakes on automobiles will not involve any more complication than are now found in the braking arrangements of most of the large cars fitted with two independent differential brakes and emergency brakes.

A NEW APPLICATION OF THE CHANNELING MACHINE

Not very long ago this paper published an article, entitled "Improvements in the Channeling Machine," in which was pointed out the great saving which could be effected in quarrying and other forms of rock excavation by the use of channelers of the latest type. It may be of interest to our readers, therefore, to know of a recent application of these machines to some special work in New York City. For some years engineers and contractors have been vexed with the problem of removing rock in excavating for new buildings, railway cuts, etc., without disturbing adjacent foundations. To accomplish this by cutting the side walls with track channelers had, up to the present time, been considered impracticable, but the success of channelers for this work on the New York Central cut under Depew Place, has conclusively proved the practicability and superiority of this method.

In a recent issue of *Mine and Quarry,* published quarterly by the Sullivan Machinery Company, there is contained a very interesting article by Joseph H. Brown, Jr., describing the work of this company's machine on the above contract. It seems that the work involved in the excavation of Depew Place for its full width of 50 ft. between 42d and 44th streets, a distance of about 500 ft. Below the natural soil and fill, which extended to a depth of 15 to 25 ft., existed ordinary gneiss rock, the stratification of which was broken and irregular. The average depth of rock to be excavated was about 15 ft. and the total amount, approximately, 18,000 cu. yds. On one side of the street, the baggage room of Grand Central Station extended the full length of Depew Place, and upon the opposite side was the Grand Central Palace, 200 ft. in length.

On account of the proximity of the foundations of these buildings to the line of the cut, the contractors found it impossible to blast without first freeing the rock at the side and they determined that channeling machines, operated by compressed air and fitted with air reheaters, would prove the most economical method of making the cut. Accordingly a Sullivan Class Y machine with 8 inch cylinder, using a solid Z-shaped steel, was started to work on June 30th and was operated continuously 24 hours a day in three shifts of eight hours each up to August 1st, the cuts being made in two and in some places three lifts, varying from 6 to 9 ft. in depth.

The progress made was so satisfactory that about August 1st a second machine was installed of the same type, so that the walls on both sides of the street could be channeled at the same time. Mr. Brown states that these channelers frequently cut as high as 10 ft. an hour in the irregular gneiss formation, which proved to be one of the most difficult in which channelers have been made to operate.

In regard to the cost of drilling and broaching by the old method, Mr. Brown estimates it as follows: Assuming that 60 ft. can be drilled per 8 hour shift, 6—10 ft. holes can be put down; and allowing three inches for the diameter of the hole and one inch for the rib between, 20 sq. ft. will be drilled per 8 hour shift. Furthermore, it will take at least one-half as long to broach as to drill, or one-half shift.

Drilling costs per shift:

Runner	$3.00
Helper	2.00
Power, oil, blacksmith, etc.	2.00
	7.00
Broaching	3.50
Total cost per 8 hour shift	10.50

Cost per foot, $0.525.

The estimated cost of running a channeler eight hours may be taken at $10, including runner, helper, blacksmith and power. Therefore, averaging 60 sq. ft. per 8-hour shift, the cost per foot was $.16⅔, a saving of $.36 per foot, or 68.3% over the method of drilling and broaching, in addition to cutting the time in half.

It is interesting to note, therefore, that the results fully approved the judgment of the contractors and that the channeler has proved its right to an important place in a contractor's equipment.

COMING EXPOSITION OF SAFETY DEVICES

Last month the press very generally notified the public of the Exposition of Safety Devices which the American Institute of Social Service proposes to hold in New York, January 28th-February 9th, 1907. Gratifying interest is being shown by the inventors and manufacturers of devices for protecting the lives and limbs of workers and of the general public.

Applications for space are being filed in the order of their receipt.

Commissioner General Kohlsaat, alive to the importance of the Exposition to be held in New York, desires to secure it entire for the enrichment of the Jamestown Exposition in 1907.

European co-operation has been generously pledged. The Belgian Minister of Labor has promised a large part of the Belgian Exposition of Safety Devices and Housing.

Dr. Muensterberg, perhaps the greatest European authority on public and private charity, has promised to send for the Section of Industrial Hygiene selected and typical exhibits of santoria for consumptives and also for drunkards, First Aid to the Injured Stations, of Red Cross Stations, of Workmen's Colonies, and other valuable material.

Dr. Hartmann of the Berlin Museum of Security will send a splendid collection of photographs and hundreds of scale drawings of safety devices.

M. Mamy, Director of the Paris Museum of Security, has already shipped valuable material.

Various influential Europeans are co-operating with the Director of the American Institute to secure the best safety devices from the continental manufacturers.

Prominent Americans also are lending their co-operation as honorary vice-presidents: Grover Cleveland, first vice-president; Hon. Frank W. Higgins, Governor of New York; Hon. Curtis Guild, Jr., Governor of Massachusetts; Hon. E. C. Stokes, Governor of New Jersey; Hon. Henry Roberts, Governor of Connecticut; Hon. C. P. Neill, U. S. Department of Labor, Washington, D. C.; Hon. T. P. Sherman, Labor Commissioner of the State of New York; H. C. Bumpus, Director American Museum of Natural History.

Requests for information regarding space should be made to Dr. William H. Tolman, Director, 287 Fourth avenue, New York.

COST OF RIVETING ON THE BROOKLYN TOWERS AND END SPAN OF THE WILLIAMSBURG BRIDGE, NEW YORK CITY

It is interesting to note in an article by Mr. Francis L. Pruyn, Associate Member Am. Soc. C. E., in a recent issue of *Railway Maintenance and Structures,* the cost of riveting the main towers and end span of the Williamsburg bridge. The riveting was done with pneumatic riveters, from four to eight being generally in use. Four men, including the rivet heater, constituted a gang, each man receiving $3.76 per eight-hour shift. Compressed air was furnished at about 80 lbs. pressure by two compressors, with a combined capacity of approximately 300 cubic feet per minute. The rivets used on the intermediate tower were short and easily driven as indicated by the cost given in the accompanying table, while the heavy sections on the main tower and end span required long heavy rivets which were very difficult to drive. The total cost of the plant was as follows:

		Main Towers.		Intermediate Tower.		End Span.		Total	
No. Rivets Driven, Net		100,039		18,971		91,835		210,845	
		Per Rivet.	Total.	Per Rivet.	Total.	Per Rivet.	Total.	Per Rivet.	Total.
Total, labor		$0.158	$15,874 00	$0.085	$1,609.00	$0.159	$14,631.00	$0.152	$32,114.00
Labor, scaffolds		.021	2,071.00	.003	64.00	.005	465.00	.012	2,600.00
Plant		.046	4,615.00	.045	865.00	.045	4,130.00	.045	9,610.00
Total		....	$22,560.00	....	$2,538.00	....	$19,226.00	....	$44,324 00
General expenses, at 10%		$0.022	2,256.00	$0.013	254.00	$0.02	1,922.00	$0.021	4,432.00
$0.247 $24,816 00 $0.146 $2,792.00	Total					$0.229	$21,148.00	$0.23	$48,746 00

Two boilers at 50%	$ 300 00
Two compressors at 50%	1,300 00
Nine pneumatic rammers at 50%	1,800 00
Fifteen forges at 50%	250 00
W. I. pipe	200 00
Coal	1,120 00
Steel, tools, scaffold, etc.	1,350 00
Plant, labor, miscellaneous	2,290 00
Total	$9,610 00

AIR COMPRESSOR LUBRICATION

Air compressor lubrication has received considerable attention of late in the technical press but not as much as it should. It is a very important subject to users of compressed air and one that comparatively few engineers have paid much attention to. Improper lubrication has been responsible for many accidents and explosions, the seriousness of which is evidenced by the following abstract from the *National Engineer:* "The pipe line leading from the receiver around the shop was not only bursted, but was opened perfectly flat, just as flat as the plate was before the pipe was made. This was small pipe, some 2", 1½" and 1", which should stand at least 15,000 lbs. pressure. The minute the explosion occurred a flame of fire shot out of the receiver. The explosion wrecked the entire roof of the building which shows plainly that there must have been a very heavy pressure. We could not get more than 100 lbs. pressure on the receiver. We feel satisfied that there must have been at least 1000—2000 lbs. pressure to have caused the wreck."

Alexander M. Gow, M. E., writing in the *Engineering News*, states that "excess of lubrication in addition to waste, means increased accumulation of combustible matter, increased lodgment of dust and increased danger of accident. . . . It will not be argued that all the lubrication used in the air cylinder is deposited on the walls of the receiver, but *some* of it will be, and the more lubricant used the more will be deposited. . . . It follows that just as little lubricant should be used as possible, inasmuch as an air cylinder requires less oil than a cylinder of equal size using steam. . . . Two lubricants are in general use in air compressor cylinders, a mixture of soap and water, and cylinder oil. Either can be made to do the work. While ignitions are bad, and must be avoided if possible, explosions are more serious. Evidently they are due to the formation of a mixture of combustible gas or vapor in suitable proportions with air at a temperature sufficient to ignite. The percentage of gas or vapor required to make an explosive mixture is surprisingly small and in general the heavier the gas or vapor the smaller the percentage. . . . *Combustible gas or vapor is evolved from all lubricating oils by heat.* It is by no means uncommon for the engineer in charge of an air compressor to introduce through the inlet pipe a quantity of light oil or even kerosene. This is a favorite and sometimes effective way of cleaning dirty discharge valves. Under such conditions it is possible for an explosion to take place immediately. Such practice is simply tempting Providence and Providence at times refuses to resist the temptation."

Many other authorities might be quoted on these points but those who have had experience in air compression will find these sufficient to convince them of the importance of proper lubrication. It is interesting to note therefore that graphite is coming more and more into general use for this purpose, and we are just in receipt of an exceptionally interesting treatise published by the Dixon Crucible Company, Jersey City, N. J., devoted to the subject of graphite and its application to air compressor lubrication. The arguments which the Dixon Company put forth are very convincing, as this lubricant is inert under high temperatures and therefore eliminates all danger of explosions; furthermore, it fills up any unevennesses, roughnesses and pores in the metal, bringing the surfaces much nearer to a condition "perfect" smoothness, than is possible by any other known means. This effects a material reduction in the "solid friction" between those surfaces, for it is a fundamental principle in lubrication that the smoother bearing surfaces can be made, the less will be the friction between them and the easier will they be to lubricate.

Graphite shows a strong tendency to attach itself to metal surfaces and, when thoroughly worked into the inequalities of surfaces, imparts a superficial glaze, or veneering, of great smoothness, high polish and endurance that prevents actual contact, metal to metal, and makes it possible for relatively small quantities of fluid lubricants to provide a safe and sufficient film or lubricating layer.

Flake graphite may be mixed with oils, soap suds or water for lubrication purposes and there are now on the market several lubricators such as the Graphoil Lubricator for feeding this new lubricant.

NEW PUBLICATIONS

Management of Electrical Machinery.—A revised and enlarged edition of Practical Management of Dynamos and Motors by Crocker & Wheeler. D. Van Nostrand & Co., New York; price $1.00.

This book has long been considered as standard in its field and scarcely needs comment except to call attention to some of the changes which have been made in the last edition. The first chapters on Principles of Electrical Machinery, Selection, Installation and Operation have been revised, and the latter part of the book, referring to troubles with machinery, has had considerable new matter added on the subject of alternating current generators and motors. Furthermore, obsolete types of machinery have been eliminated from the book. The book as now printed is divided into five parts: Part 1, covering Selection, Installation, Connection, and Operation. Part 2, Inspecting and Testing. Part 3, Localization and Remedy of Troubles. Part 4, Constant-Current (Arc) Generators. Part 5, Management of Railway Motors. These five parts occupy 218 pages, with 131 illustrations, and the book should be of great assistance to the operating engineer in explaining the difficulties which he is likely to encounter in handling electrical machinery. It also contains sufficient theory to show the reasons for the remedy besides giving the theoretical student an idea of the practical side of his profession.

Gas-Engine Design, with an introduction on Compressed Air by E. J. Stoddard, published by Parker & Burden, 1217 Hodges Block, Detroit, Mich. Price, bound in paper, 25c; flexible cloth (buckram), $1.00.

The only part of this book which directly concerns the user of compressed air is the section devoted to an introduction on compressed air, and also the first chapter, which treats of a graphical construction of the curves, $PV^n = C$, which are worked out for various values of n corresponding to isothermal compression of air, adiabatic compression of air, adiabatic compression for gas engine, saturation curve of steam, etc.

The chapter devoted to compressed air treats of the theoretical side only and is exceedingly complete. Aside from the derivation of the characteristic compressed air formulæ, this book contains numerous tables and curves showing volume, final temperature, and pressure in atmospheres corresponding to various gage pressures. It also gives the square root, cube root and fourth root of numbers from .1 to 20.4. Furthermore, a table is included showing the mean effective pressure, work per pound of air compressed and other important facts corresponding to the compression of air from 0 gage pressure up to 200 lbs. per square inch.

The book is ably written and should be a valuable addition to any engineer's library.

TRADE PUBLICATIONS

Note.—We believe it to be the desire of every up-to-date engineer to acquire a comprehensive collection of trade catalogs covering the subjects in which he is most interested. We therefore endeavor to review the catalogs submitted to us briefly, but carefully, in order that our readers may form some adequate idea of their contents and value.

Cyclone Drill Company, Orrville, Ohio.—Eighty-five-page catalog, 6 x 9, fully illustrated, describing their full line of prospecting machinery for coal, water, oil, gas, mineral and placer mining. The catalog describes particularly their portable churn drills and rotary core drills and covers the subjects of sand pumps, drilling tools, blowers and spare parts. Catalog 6 x 9, fourteen pages devoted to Cyclone contractor drills and Economy blast hole loaders. Also catalog 6 x 9, twenty-two pages, covering their drilling machines for contractors and rock excavation work.

Pratt Institute Free Library, Brooklyn, N. Y.—Catalog of books on electricity contained in the Applied Science Reference Room. This room has been lately opened to the public and contains an especially complete assortment of engineering reference books.

Ingersoll-Rand Company, 11 Broadway, New York.—Small booklet, Form 35-A, illustrating and describing Ingersoll-Sergeant air compressors, both straight line and duplex.

C. W. Hunt Company, West New Brighton, S. I.—Forty-four-page booklet devoted to Hunt industrial railways and their equipment. This booklet, while small, is well illustrated and singularly complete.

The Whitaker Manufacturing Company, Chicago, Ill.—Small booklet entitled Modern Tools, and illustrating their line of twist drills, air drill reamers, drill chucks, taps, saw blades, ratchet drills, wrenches, etc.

People's Specialty Company, Corning, N. Y.—Small booklet illustrating and describing the Simplex drawing and time card holder, being a frame for holding blue prints and time cards which may be attached to a lathe or other machine tool in such a position as to be equally seen and read by the machinist. The use of this apparatus does away with mounting blue prints.

Allis-Chalmers Company, Milwaukee, Wis.—Forty-page bulletin (Bulletin No. 1507), 7¾ x 10¼, devoted to a description of the general subject of air compression and to the compressors manufactured by this company. The bulletin contains many valuable tables and other data of interest to engineers and will doubtless be very much in demand.

Hanna Engineering Works, 820 Elston avenue, Chicago, Ill.—Four-page leaflet describing the Hanna radial reamer for reaming rivet holes in bridge and structural girders, etc.

Baldwin Locomotive Works, Philadelphia, Pa.—Record of Recent Construction, No. 59, 34 pages, 6 x 9. This booklet is most handsomely printed and describes and illustrates many of the recent locomotives which have been built by this company.

Ingersoll-Rand Company, 11 Broadway, New York.— Bulletin No. 2011, issued by the Pneumatic Tool Department, and devoted to a description of the "Little Jap" hammer drill for light work in all rock excavations. The bulletin contains twenty pages, fully illustrated, and is 6 x 9 inches in size.

Sullivan Machinery Company, Railway exchange Bldg., Chicago, Ill.—Bulletin No. 51-D, twelve pages, 6 x 9, illustrating and describing Sullivan pneumatic hammer drills for quarrying and contracting work. The pamphlet is well illustrated and full particulars are given of the drills.

Joseph Dixon Crucible Company, Jersey City, N. J.—Twenty-six page pamphlet devoted to the subject of air compressor lubrication. This pamphlet is particularly valuable to engineers and operators of air compressors as it contains a thorough description of the use of flake graphite for the lubrication of air cylinders.

Chicago Pneumatic Tool Company, Fisher Bldg., Chicago, Ill.—Catalog No. 20. 116 pages, 6 x 9. describing the full line of Franklin air compressors manufactured by this company. Constructive principles are described in detail and information not hitherto published is given relative to several new types of compressors including Corliss, motor-driven, gas engine driven, and new pattern compressors of larger capacities. This catalog also devotes considerable space to the subject of pumping by compressed air, besides including numerous tables and formulæ of interest to compressed air users.

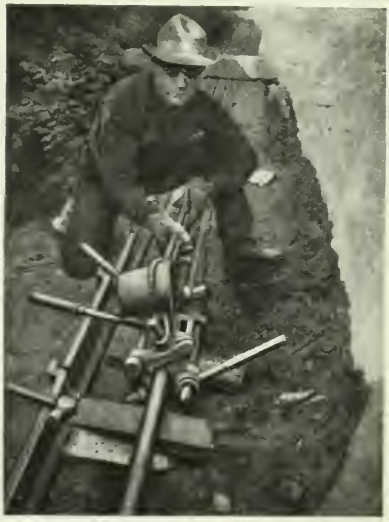
Roteng Engineering Co., 299 Broadway, New York.—Bulletins Nos. 55 and 56, illustrating and describing rotary belt-driven and motor-driven air compressors of a new design. These compressors are very simple in construction and represent an entirely new principle in the design of air compressing machinery.

The Rix Compressed Air and Drill Company announce that they are how occupying their new offices at 219-221 Spear street, San Francisco, Calif., which is their main office and salesroom. Their factory, warehouse, and branch office are located at 1436 Fifth street, Oakland, Calif. They state that their factory has greater capacity than before the fire and that they are now able to fill all orders for air or gas compressors, rock drills, etc.

INDUSTRIAL.

BUTT WELDING WROUGHT IRON PIPES BY THE THERMIT PROCESS

Thermit, as most people know, is a mixture of finely divided aluminum and iron oxide which when ignited in one spot communicates the combustion throughout its mass without the introduction of heat or power from outside and produces during this combustion (in about fifteen seconds), a temperature of approximately 5,400° F.



WELDING A 1¼-INCH PIPE.

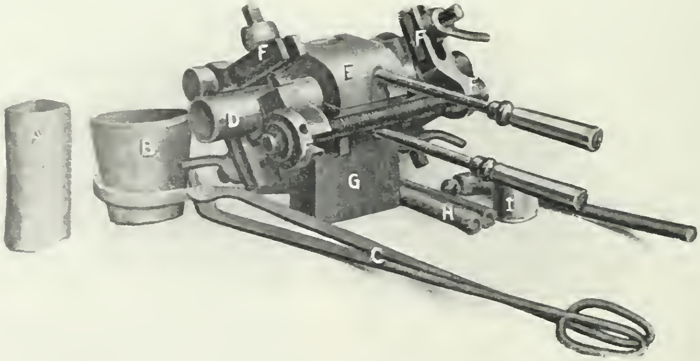
During the reaction which produces this heat, the aluminum and the oxygen contained in the iron oxide combine to form a highly superheated liquid slag (aluminum oxide). The iron which is set free at the same time and at the same temperature sinks to the bottom of the containing vessel or crucible.

In the case of pipes and small rods, the superheated molten mass is poured around the pieces to be welded, the latter are thus brought to the necessary temperature and the weld is completed by physical pressure as described below.

It is necessary that the ends of the pipe be prepared somewhat for the process of welding and they are accordingly filed and then butted carefully together between clamps. A cast iron mold, in two pieces, is then placed around this joint, the upper part of the mold having a narrow gate to admit the superheated mass.

The thermit is ignited in a flat bottomed crucible held in a pair of tongs. After the reaction the slag fills the upper part of the crucible and occupies three times the volume of the superheated liquid steel which collects at the bottom after the reaction has taken place.

The superheated liquid mass is then poured into the opening of the mold. The slag flowing first, will adhere in a thin layer to the walls of the mold and the surface of the pieces to be welded and will protect them from contact with the liquid steel which runs in last. After waiting for the ends to soften, the clamps are drawn up and effect the weld by squeezing together the now plastic ends of the pipes. The welded joints are as strong as the rest of the pipe and, after removing the molds and clamps, the weld will be perfectly solid and there will be practically no upset at the joints. On chilling, the layer of slag is easily knocked off.



EQUIPMENT REQUIRED FOR WELDING PIPE BY THE THERMIT PROCESS.

A, Welding Portion Bag; B, Crucible; C, Tongs; D, 2″ Pipe: E, Top Talf of Cast Iron Mould Box; F F F F, Screw Clamps; G, Support for Bottom Half of Cast Iron Mould Box; H, Pins for Screwing Up Clamps; I, Ignition Powder.

An interesting point in the application of this process of welding is the fact that it is adapted to either steam, compressed air or ammonia pipe lines and the joints may be welded anywhere in place and vertical pipes are welded as easily as horizontal.

The thermit powder is put up in bags containing the quantities necessary to weld a given joint which is called a "welding portion." The necessary appliances consist of a set of clamps, tongs, cast iron mold and crucibles. The first two articles are permanent; the molds should last for sixty or more welds and the crucibles will withstand twelve to fifteen reactions. One half teaspoonful of ignition powder is required to start a reaction and one pound is sufficient for one hundred welds.

Owing to the fact that the cost of welded joints is dependent upon and varies with the conditions surrounding each case, it would be difficult to make any estimate of the cost of the process for purposes of comparison with other systems of joining pipe lengths. It might be said, however, that the first cost of welding will undoubtedly be higher than any other system in use, but the *first cost* in the case of the thermit process is the only cost that will have to be met, since the joints, once welded, are permanent and as indestructible as the rest of the pipe. This cannot be said of any other system of pipe connections, and is a point that should be considered carefully by managers of steam, compressed air and refrigerating plants.

The Thermit process is controlled by the Goldschmidt Thermit Co., 43 Exchange Place, New York.

A NEW COURSE OF INSTRUCTION AT PRATT INSTITUTE

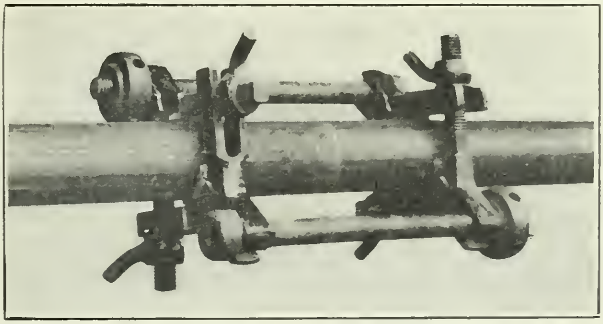
The department of science and technology of Pratt Institute, Brooklyn, N. Y., this year offers a new course in machine construction intended primarily to train its graduates to fill positions as foremen and assistant superintendents in machine shops or in kindred manufacturing plants in which machine work is an operation of first importance. It is preferred that applicants for this course be men with some considerable previous experience in machine work, it being the idea to combine with their practical experience the theory underlying it. A good working knowledge of arithmetic is also required, and only those are desired whose ambition is to improve their condition and to that end are willing to devote their energies for the nine months required to complete the course. The machine shop of the institute has recently been added to, and the increased floor space and new equipment nearly double its capacity.

The course of study covers machine construction, tool working, lectures on machine shop practice, mechanical drawing, practical mathematics, foundry work and forging. A unique feature in the curriculum of the institute is the provision for developing in the students the ability to direct the work of others by giving each one practice at being a foreman, first over one or two of his classmates, and finally he is given a chance to lay out and direct the work of a larger number. In this way he is able to gain experience and confidence in handling men and in directing work, fortifying himself against the natural disinclination employers have for intrusting the responsibility of handling men to those who have never had actual experience.

WESTINGHOUSE COMPRESSOR FOR GARAGES

The Westinghouse Air Brake Company have put upon the market a portable air compressor particularly well adapted for automobile garages for inflating tires, dusting out vehicles and cleaning machinery of all kinds. The ease with which it can be moved about to any desired point makes it especially desirable for this purpose. These portable plants are extensively used in car barns throughout the country for cleaning cars and machinery. Their steam-driven compressors for industrial purposes are the same seen in daily operation on any locomotive for supplying compressed air to operate the train brakes, which attests their sturdiness and reliability.

During the past few years the knowledge of their efficiency and compactness has led to their rapid introduction into the industrial field, where they are employed for all conceivable purposes, as, for instance, raising water by direct pressure, operating pneumatic tools, paint sprayers, etc.; also for sewage ejecting systems, cleaning molds and machinery in foundries and shops and other uses too numerous to mention.



CLAMP IN POSITION FOR WELDING PIPE BY THE THERMIT PROCESS.

This is one of the most efficient labor saving devices lately offered to garage owners and ought to attain prompt popularity.

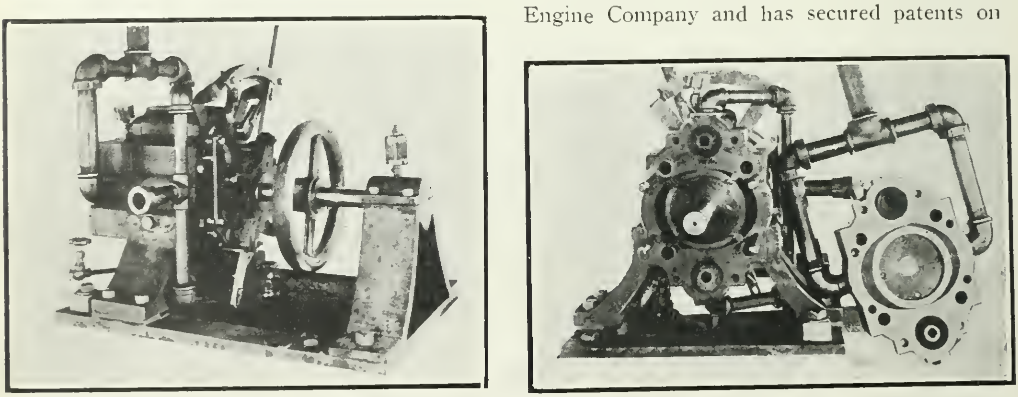
INDEPENDENT PNEUMATIC TOOL CO.

The Aurora Automatic Machinery Company of Aurora, a subsidiary of the Independent Pneumatic Tool Company, reports that owing to expanding business the company's plant will be greatly enlarged. The company has a capital of $500,000, but no new stock will be issued to finance the improvement. Stockholders at their annual meeting elected the following directors: John P. Hopkins, M. S. Rosenwald, Simon Florsheim, J. J. McCarthy, John D. Hurley, A. B. Holmes, all of Chicago; James B. Brady and W. O Jacquette of New York

City, and C. E. Erikson of Aurora, Ill. The following officers of the company also were elected: President, John P. Hopkins; first vice-president, W. O. Jacquette; second vice-president, John D. Hurley; treasurer, C. E. Erikson; secretary, A. B. Holmes. The directors declared a regular quarterly dividend of 3 per cent.

A NEW ROTARY STEAM ENGINE

Revolution in the use of steam as a power agency is predicted for the rotary engine invented by H. I. Call, of Spokane. The idea embodied in the Call engine is absolutely different from that of the ordinary reciprocating piston engine. There is no piston. Instead there is a steamchest, inside of which is a cylinder, which rotates by pressure of steam against slidable blades, power being made available by a shaft attached to the rotating cylinder.



TWO VIEWS OF NEW ROTARY ENGINE.

The cylinder is readily rotated by the pressure of steam against the projecting ends of the sliding blades in the crescent-shaped steam chambers. As the cylinder revolves it constantly slides the blades back and forth through the arc-shaped slots holding them into the cylinder. The sliding movement of the blades corresponds with the pressure of the oval inner wall of the steam chest upon the points of the blades. When one end of the blade is passing the narrowest distance between the cylinder and the steam chest wall the other end is passing through the widest distance in the crescent-shaped steam chamber. The ends of the blades are fitted so tightly against the wall of the steam chest that not an atom can come between them. To reverse the engine steam is admitted through opposite valves, the exhaust escaping through separate pipes.

Mr. Call has completed two of the new model engines. One of them is running in his shop in Spokane. It shows remarkable strength, operating several large lathes, drills, saws and other heavy machinery. The engine is 6x7x11 inches, and occupies a floor space 15x20 inches with its fittings, with 14 inches to the top of the steam pipe and weighs 217 pointed by the Spokane chamber of comarea for six horse power, but Mr. Call declares he has developed 10 horse power.

Mr. Call has formed the Crescent Rotary Engine Company and has secured patents on his invention in the United States and England, as well as other foreign countries and it is proposed to build a factory for its manufacture.

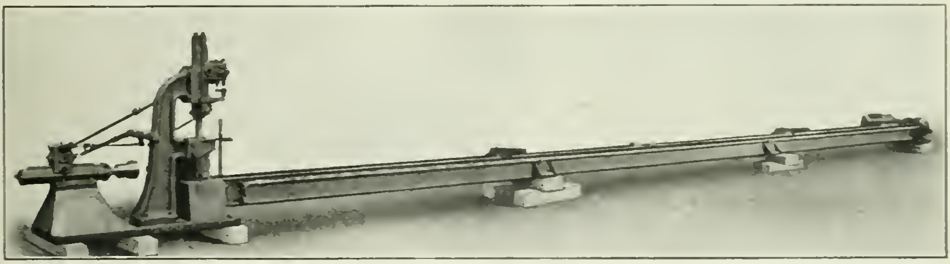
C. M. Fassett, J. M. Fitzpatrick and Samuel Glasgow, members of a special committee appointed by the Spokane chamber of commerce, have made a report to that body in which they say the engine is a great improvement over the reciprocal steam engine and that because of its cheapness, simplicity, compactness, easy control of speed and reversing and freedom of vibration the demand for it should be enormous. They also recommend the engine to the manufacturers of Spokane and endorse the project to manufacture it in Spokane.

Messrs. Siemens and Halske, of Berlin, Germany, have recently patented an alloy which is especially suited for use as a bearing metal. They state that it is superior to the usual white metal in that it is very easily worked and particularly easily turned, that it fills up the mold completely when cast, that it possesses relatively great hardness, and, what is most important, that it has an extremely small coefficient of friction. The alloy is made by melting together approximately equal parts of cadmium and zinc, with an addition of a small proportion of antimony. The alloy can, for example, consist of 45-50 parts of cadmium, 45-50 parts of zinc, and up to 10 parts of antimony. The antimony added should not exceed 10 per cent, as otherwise the metal is too brittle. A very suitable proportion of antimony is 5 per cent. If the proportion of cadmium and zinc is considerably varied, the coefficient of friction increases, and the other good properties of the alloy are essentially prejudiced.

"THE MULTEX"
(MULTIPLE EXPANSION)
COMPRESSED AIR-LIFT PUMP
(PRICE'S PATENT TAPER-TUBE SYSTEM.)

In a recent issue of our English contemporary *Engineering*, there appeared the following description of the test of a new air lift pump. Our contemporary states that although it cannot be claimed that the air-lift pump when used for raising water from deep wells and similar places, is able to compete in point of efficiency with high-class barrel pumps, it is, however, for many purposes so convenient and useful that there are many cases in which its advantages out-weigh those of mechanically-driven pumps. Unfortunately, in some instances where air-lift pumps have been tried, it has been found that their efficiency has been rather low; and there has, no doubt, on this score, been somewhat of a prejudice against them, which, though not unnatural, has probably frequently prevented their use in places and under conditions for which they were well adapted. Although their efficiency has been lower than that of the deep-well barrel-pump, it has been improved of late years, and particularly so by the adoption of the tapered delivery-pipe, which now bids fair to bring the air-lift pump into greater favor.

The principle of the pump is, of course, understood by engineers; although perhaps the latest improvements that have been made in it are not so well known. In its simplest form it consists of a pipe, which is placed in the water to be pumped, a part of the pipe being in the water and a part out. Inside or outside this pipe is another tube, down which compressed air is forced, the bottom of the air-tube being so arranged as to de-



WORD BROS.' DRILL MAKER AND SHARPENER.

A NEW DRILL SHARPENER.

A noteworthy machine for making and sharpening rock drills has lately been built in San Francisco and shipped to the Panama Canal. The conditions in the Canal Zone, with reference to rock drills, were such that the ordinary drill sharpener would not meet the requirements, mainly for the reason that the drills used there are of greater size and longer length than those generally used in mining.

The machine is of the Word Bros.' type of drillmaker and sharpener, and was designed and constructed with a view to handling long lengths and large size steel. It forges and sharpens drills from 1¼ in. diameter to 5 in. diameter, and from 1 ft. to 30 ft. long without any change of dies or appliances in the different sizes and lengths of drills. Its weight is 6000 lbs. and is 38 feet long overall, and was the first drill sharpening machine constructed in San Francisco after the great fire.

liver the air inside the water-tube, which is open to the well at the bottom. Before the air is admitted the level of the water is the same in both tubes, but when the air-pressure is applied, the water in the air-tube is forced down and mixes with the water in the water-tube. When the air has forced all the water out of the air-pipe, it flows out itself, mixes with the water in the water-pipe, making the column lighter, and causing the water to rise to a height which bears a relation to the immersion, and consequently to the pressure of the air supplied.

A Mr. Crockford appears to have applied the principle in America in 1846, for the purpose of pumping petroleum from several Pennsylvania wells. After that time the invention lay dormant for some considerable time—indeed, until revived by Dr. Pohlé about 1898. It was then applied by him for raising water on a large scale in America.

The rising main of the ordinary air-lift pump is of equal diameter throughout, and experiments have shown that layers of air rise in the main alternately with water; and as the layer of air rises in the main, the pressure above it, of course, grows less, at the top the pressure being only that of the atmosphere. If it can do so, the air will expand gradually on its way up, until at the top the length of tube that it occupies will be several times greater than that which it occupied at the bottom; or, in other words, much of the energy of the air is absorbed by giving the water a rapid motion, which is not required. This point has been very carefully studied by Mr. Joseph Price, of Messrs. Le Grand and Sutcliff, Bunhill-row, London, who has for a long time been investigating the matter, with the result that the firm mentioned have introduced a form of air-lift in which the rising main is gradually widened from the bottom towards the top. By this arrangement it will be seen that the air can expand laterally, and the layers of water will have only a slightly higher velocity at the top of the pipe than at the bottom. The energy expended in giving a higher momentum to the water as it rises is thus saved.

Very striking results have been obtained with this form of pump, much higher efficiencies being obtained by it than with the original apparatus, and several extensive experiments have been made in order to test the new arrangement. One of these, which we recently saw carried out at the Wandsworth and Putney Gas Works, is of so much interest that we place the results before our readers.

The air-lift pump on which the tests were made was placed in an artesian-well boring 7¼ in. in diameter, which extends to a depth of 630 ft. below the surface, and terminates in hard chalk. The well is lined continuously with steel tubes to a depth of 284 ft. below the surface, the upper part being surrounded by another steel tube 11½ in. in diameter, which reaches to 54 ft. below the surface; the space between the inner and the outer tubes being filled with cement-concrete, so as to protect the tube proper from any corrosive action of the waters of the surface beds. The "rest" water-level, before pumping, stood at about 154 ft. below the surface; and, during a preliminary test, indications of a probable supply of 5000 gallons per hour being obtained, arrangements were made for raising that quantity.

The pump employed was one of the "Multex" air-lift pumps on Price's patent taper-tube system, and the compression of the air was effected by a horizontal tandem steam-driven compressor of 12-in. stroke, with two-stage compression. All the cylinders were double-acting, the steam cylinder being fitted with a piston slide-valve, and the air-cylinders with Matthewson's inlet and delivery valves. The air, partly compressed in the first cylinder, was passed through an intercooler fitted with copper tubes; the cooled air then entering the high-pressure cylinder was further compressed to the working pressure, and delivered to a steel receiver, where any oil carried from the cylinders was deposited. From the receiver the air was conveyed a distance of 120 ft. to the air-lift pump, where it was connected by a length of metallic hose to the air-pipe passing down the well (in this case outside the rising main) to an annular ejector at the bottom. By a special arrangement the whole could be raised or lowered, and the annular passage through the delivery valve of the ejector increased or decreased, as desired, to ensure the most effective action.

The proper size of the annular opening once having been found, no further adjustment is required. The effective length of the rising ft., and a pressure gauge on the air receiver gave the pressure of the air and its equivalent head in feet. The immersion could thus be measured by simple inspection. The head, due to the working pressure on the gauge, was 330 ft., 6 ft. of which was found to be due to friction in the pipes, leaving 324 ft. as head; and this, subtracted from 580 ft., the total length of the rising main, gives the effective lift as 256 ft., the delivery was some 33 ft. above the surface; so that the water level in the well while pumping, stands at 223 ft. below the surface, or 69 ft. below its normal level.

The water, after being delivered to an open cistern, to allow the air to separate from it before delivery into the distributing system of the gas works, was, for test purposes, passed through a valve into a tank provided with steadying screens, and a weir 1 ft. wide; the height of the still water was recorded on a strip of paper on a drum rotated by clockwork, thus furnishing a timed record of the actual flow over the weir.

During the test the air-compressor was run at 150 revolutions and at 160 revolutions per minute; the recorder showed an average flow of about 2 in. over the weir, or about 15 cubic feet per minute, and the efficiency of the compressor was then taken on the method usually adopted, of counting the number of strokes required to fill a measured receiver from atmospheric pressure to the working pressure, and correcting for differences of temperature, to ascertain the volume of free air actually compressed for this purpose. The measurement of the receiver was 9.6 cubic feet, or, with the pipes and valve chambers, exactly 10 cubic feet; which space was filled to 135 lbs., the working pressure, by 164 strokes (the average of three observations), which, with corrections for temperature, means a compression of 0.51 cubic feet of free air per revolution of the engine. Thus, at 150 revolutions, and 0.51 cubic foot per revolution, 76.5 cubic feet of air were compressed to raise 13¼ cubic feet of water, or a ratio of air to water of 5.8 to 1, and this while raising the water 256 ft., with an immersion of 324 ft., or a ratio of 56 per cent. of the total length of the rising main. Further particulars of the tests are given below:

Revolutions of compressor per minute	150	160
Free air compressed, in cubic feet	76.5	81.6
Height of flow over 12-in. weir	1⅞ in.	2 in. full
Equivalent delivery in cubic feet	13.2	14.54
Volume of air per volume of water	5.8	5.61
Horse-power equivalent of water lifted	6.4	7.04
Horse-power as per indicator diagrams from steam cylinder	17.8	19.6
Efficiency of plant	36 p. c.	36 p. c.
Ratio of immersion to height of rising main....	56 p. c.	56 p. c.

As the quantity of air required increases materially as the proportion of immersion to lift decreases, to enable comparisons to be made, it is essential to reduce records to a common standard, preferably 60 per cent. of immersion to 40 per cent. of lift, which has been found to give the best results. The correction of the above figures to this standard gives the volumes of free air required per cubic foot of water raised as 5.05 and 4.87 cubic feet respectively; and as under similar conditions the best records of other air-lift pumps indicate a probable requirement of about 8 cubic feet of free air to be compressed, the claim that the tapering tube-pump will raise half as much more water as can be done with parallel tubes, with the same power, seems to be supported; the exact ratio in this case in 160 to 100.

Although the air-lift pump is not so efficient as a first-rate barrel pump, it is obvious that it has advantages under certain conditions, one of the greatest of these being that the working parts and machinery may be at a great distance from the well.

Another advantage is that it is quickly and easily installed. Now that the efficiency of this system has, by the use of the tapered pipe, been so much increased, there does not seem any reason why the air-lift pump should not be more used than it has hitherto been.

FLOOR SCRUBBING MADE EASY

Elias B. Dunn Exhibits Mechanical Invention Which Simplifies Laborious Process

If Elias B. Dunn has his way the day of the scrubwoman is over. So is the day of shaking out carpets and laborious washing of floors for the housewife. Mr. Dunn gave a demonstration of the inventions which have brought this about in the offices of the Dunn-Locke Vacuum Cleaning Company, in the Knickerbocker Building, No. 116 West Thirty-ninth street, yesterday.

The device is like the ordinary vacuum cleaning apparatus, except that its rubs the floor, sucks up the soap and water and carries all the refuse back through a rubber tube and thence to the cellar with a pump, which discharges the stuff.

Mr. Dunn threw flour and other things over the upholstery of his office furniture, and showed how the appartus cleaned it all off in a few seconds and left not a stain behind.

THE Traylor Engineering Co., which has recently begun the manufacture of fuel briquetting machinery, and the installation of fuel briquetting plants under the Mashek system of briquetting, has already received several important orders. Three of their orders, for which the machinery is now being built at the company's works, at Allentown, Pa., are, respectively, for Edward B. Arnold, No. 1 Broadway, New York, for his plant at the foot of West 48th street, New York; the Semet-Solvay Co., for its Detroit plant, and the Montreal Light, Heat and Power Co., of Montreal, Canada.

These plants represent three interesting variations of the briquetting industry. Mr. Arnold is a large coal dealer. His plant is to make briquettes for domestic consumption, using the small sizes of anthracite coal. The Semet-Solvay Co. will make first-class fuel for domestic use from the coke breeze, which is a waste product from the Solvay by-product coking ovens, and the Montreal Light, Heat and Power Co. will make a smokeless briquette for family use from coke breeze resulting from gas making, using coal tar pitch as a binder.

The adoption of the Mashek process and machinery by these three concerns is of particular significance because each of them has been experimenting for a long time with the best and most used European briquetting machinery, and machinery of other design until they were all of them conversant with every system in use. Although the foreign process and machinery may be satisfactory abroad, they have proved a commercial failure here. The briquettes produced are not of a size or shape to suit American consumers, most of them requiring to be broken up before use. Their cost also was too great, because of the small production of the plants, the large amount of binder required, and the cost of the necessary attendance. The Mashek plants and machinery are entirely automatic in their operation, no hand-labor being required from the time the materials are received until the finished briquettes are ready to be delivered to the consumers. The briquettes are of a size and shape suitable for immediate use and convenient to handle by chute or shovel, and the production is nearly as large per hour as is the daily output of tthe foreign built plants. The briquettes are as hard and clean as anthracite coal and equal the best qualities of anthracite for use. The cost of briquetting under this system has been demonstrated in plants now in operation to be from 76c. to 92c. per ton, including pitch for binder, fuel for the boilers, dryers and heaters, lubricating oil, wear and tear and labor—in fact, including everything but the cost of the raw material to be briquetted. The system operates equally well on anthracite or bituminous coal, coke breeze or lignite. The design of the machinery and the installation of plants is under the personal supervision of Mr. G. J. Mashek, the inventor and patentee of this process and machinery.

TRIAL OF ROCK DRILLS, AT BENDIGO.

Trials were made at Bendigo, on December 21, 1905, at the 1,470 ft. level of the Suffolk Tribute mine, with various water sprays and atomizers. Before drills started, 24,000 dust particles to the cubic centimetre were found, and in two and a half hours had increased to 270,000. The approximate average weight would be about 70 billions to the gramme. Conclusions drawn from the various experiments made are:—(1) Large particles are only found during boring in dry holes, and are quickly settled by gravitation. They are probably too short in the air to be inhaled in dangerous quantities, and water drills or atomizers easily eliminate even the possibility. (2) Medium sized particles are thrown into the air in large numbers by dry drills, and render their imemdiate locality very dangerous to health. Their production in the air may be checked by water drllls, and the atomizer soon causes them to settle if properly directed. (3) Small particles are always found in mine air in varying quantity, and possibly include a larger portion of living organisms than in the open air. Prolonged use of water drills or atomizers tends to reduce their numbers, but produces possibly injurious humidity instead.—*The New Zealand Mines Record.*

CHIPPINGS.

MRS. Frances A. W. McIntosh, formerly advertising manager of the Standard Tool Co., Cleveland, O., and more recently connected with the advertising department of Power, New York, has taken charge of the Publication Department of the Norton Company, Worcester, Mass.

The compressed air systems are being extended at the navy yards and further improvements in the methods of transmission are under consideration. The use of tools operated by compressed air is increasing and plans have been made to make the facilities more accessible.

The deepest bore hole in the world is one that is located near Leipsig, Germany. The object of the hole was in determining whether coal was there and likewise the man making the boring was of a scientific turn of mind. The hole has attained the great depth of 5,790 ft. At the surface the hole was about a half foot in diameter and at the bottom had tapered off to less than an inch in diameter. Diamond drills were used and the rods weighed 20 tons. It took ten hours' work to take the rods apart and put them together again.

Compressed air differs from electricity, especially in the fact that electrical friction losses cannot be regained, while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments the volume of the air and does not involve a loss of transmission. "If the air were at 80 lb. gage or 95 lb. absolute upon entering the pipe, and 70 lb. gage or 85 lb. absolute at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent."

Where compressed air is used, it is important that all joints in the air mains should be carefully made to prevent any possible leaks, as air leaks are more expensive than steam leaks. At intervals, it is well to test for leaks by allowing the air at full pressure to remain in the pipe long enough to observe the gage. To render pipes accessible for inspection, they should, if buried, be carried in boxes sunk just below the surface of the ground, and all low points which might form pockets for the accumulation of entrained water should be avoided, as they obstruct the passage of the air. It is also advisable, in long, uneven lines, to provide an opening near the end, for occasionally blowing out water. Long lengths of pipes on the surface or shafts where the temperature is subject to changes, should be provided with expansion joints.

The pneumatic tube as a feature of the mail service seems finally coming into its own, after years of interesting and peculiar struggle, such as no worthy labor-saving device probably ever has to go through until it strikes the tortuous ways that lead to Government adoption. But in spite of all, the pneumatic tube which has long been an established time and money saver in private establishments, which has hustled express from city to suburb, is to be much more in evidence in Uncle Sam's mail service. Bids have been opened recently for renewal of contract and extension of the service in New York, Brooklyn, Philadelphia, Chicago and St. Louis; for renewal of contract in Boston, and for new service in Pittsburgh, Baltimore, Cincinnati, Kansas City and San Francisco. Appropriations not to exceed $1,250,000 a year for the service are now available, and extend over a period of ten years. These should give the Postmaster-General a rather free and generous hand in getting from the pneumatic tube a service most valuable and time-saving in many parts of the country.

To produce a black color on brass, the following is the formula: Dissolve 1 pound of plastic carbonate of copper in 2 gallons of strong ammonia; first boil the brass that is to be blackened in a strong potash solution to remove all grease and oil; rinse well and dip in the copper in the ammonia solution, which should be heated to 150 to 175 deg. F., until the desired degree of blackness is acquired. The color produced is very uniform and has little tendency to peel off. The process works best on brass containing much copper, or on what is known as "red" brass. Directions are also given for making the plastic carbonate of copper as follows: Blue vitriol (sulphate of copper) is dissolved in hot water and a strong solution of common washing soda is added to it so long as any precipitate forms. The precipitate is allowed to settle and the clear liquid is poured off. Hot water is now added, and the mass stirred and again allowed to settle. Again the clear water is poured off and the operation of adding hot water settling and pouring off is repeated until everything has been washed out of the green carbonate of copper which remains at the bottom of the vessel. This is the plastic carbonate of copper referred to.

WELLS AND THE WEATHER

According to the observation of M. Grosseteste upon some of the wells which are situated in the Canton of Geneva, it appears that the wells have the remarkable property of drawing in air at certain times and of blowing out air at other periods. These wells are considered by the inhabitants of these districts as very exact indications of the weather. When the wells blow out air it is a sign that rain is to follow, and when air is drawn in it is a sure indication of fine weather. Since the wells are covered with a flat stone having a hole in it, according to the custom of the region, it is easy to observe the direction which is taken by the current of air. Some observers installed upon one of the wells a pressure gauge of U-form, and were thus able to find some interesting points about the air currents. Thus they find that a well is very seldom in a state of equilibrium. It blows out when the barometer falls and sucks in air when it rises. These variations do not exceed a height of one inch on the gauge. As to the theory of the action of these wells, it is to be remarked that they lie in strata of alluvial gravel covered with vegetable earth which is quite or nearly impervious to water. We may therefore admit that, owing to the spaces which exist between the stones of the gravel, these strata form a reservoir of great capacity in which the water circulates. The water comes into the cavities when the atmospheric pressure is lowered, and it leaves them when the pressure rises. The effect of these movements is thus felt within the well, inasmuch as the latter forms the connecting point with the outer air. This phenomenon may be said to have a considerable analogy with the emission of gases by certain hot springs, to caves where a current of air circulates upon the ground, to the variations in the flow of springs and other phenomena of a like nature.—*Scientific American.*

It was recently noticed in a cold storage that candles or lamps began to burn with a feeble flame as soon as they were brought into the room and that in many parts of it they were extinguished. A match could be lit, but the wax would not ignite. In the corner of the storeroom was a disused well, from which gas issued, and Mr. Bertram Blount, who was asked to investigate the cause of the trouble, at first supposed that carbon dioxide was being distributed into the air from this well. But this was not borne out by analysis of the air in the room and from the well, says Knowledge and Science, for the amount of carbon dioxide was only slightly more than is present in normal air, and was quite insufficient to have affected the combustion of a candle. Samples of the air taken from different parts of the room contained only 17.5 to 17.7 per cent. of oxygen, or from 3.2 to 3.4 per cent. less than is present in normal air. The oxygen in the air in the shaft of the well amounted to no more than 8.6 to 8.9 per cent., and other experiments confirmed the conclusion that the air in the storeroom was ordinary air containing less than its proper proportion of oxygen, owing to admixture of air deprived of its oxygen, which issued from the well shaft. The source of the impoverished air from the well was finally traced to tunneling operations close by, in which compressed air was being used. The air must have found its way through the soil wherever it was sufficiently porous, and so into the shaft of the well, and on its passage through the soil must have been deprived of part of its oxygen by contact with some substance such as pyrites. Evidence in support of the correctness of this conclusion was furnished by the analysis of the mud from another well shaft near the first. This mud was found to contain pyrites, and air left in contact with it for some weeks was deprived of almost the whole of its oxygen.

ONE of the causes of a serious loss in the transmission of compressed air is pumping the air of the engine room rather than air drawn from a cooler place. This loss amounts to from 2 to 10 per cent.

U. S. PATENTS

ESPECIALLY PREPARED FOR

COMPRESSED AIR

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

830,618. FAN FOR PNEUMATIC STACKERS. Joseph K. Sharpe, Jr., Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Apr. 17, 1905. Serial No. 256,106.

Claim.—1. The combination, with a fan-vasing having an eye leading thereinto, of a fan rotatably mounted within the casing, and a guard consisting of a series of substantially concentric separated portions arranged between the eye of the casing and the fan.

830,661. PNEUMATIC KNEE-PAD. Ernest G. Gresham, Dunedin, New Zealand. Filed Jan. 6, 1906. Serial No. 294,970.

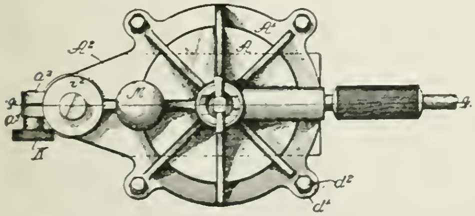
830,975. APPARATUS FOR PRODUCING HIGHLY-OZONIZED AIR OR OXYGEN. Auguste

831,040. LOAD-BRAKE APPARATUS. John S. Custer, Pittsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Dec. 18, 1903. Serial No. 185,679.

831,044. EXPLOSIVE-ENGINE. Herman Dock, Philadelphia, Pa. Filed Nov. 6, 1903. Serial No. 180,005.

Claim.—In an explosive-engine, in combination, a cylinder, a carbureter, connection between the carbureter and the cylinder, a source of air-pressure supply, a pipe leading therefrom to the carbureter, a pipe leading from the atmosphere to the carbureter, and means to connect the carbureter with either the atmosphere or the air-pressure supply.

831,272. PNEUMATIC TOOL. Nathan W. Fletcher, Chicago Heights, Ill., assignor to Turbine Motor Tool Company, Chicago, Ill., a Corporation of Illinois. Filed May 16, 1904. Serial No. 208,244.



Claim.—A tool for the purposes set forth, comprising a main frame embracing a base having a flat, bottom bearing-surface, a turbine-motor, the rotative member of which is mounted centrally over the base with its axis of rotation vertical and the non-rotative member of which is rigidly attached to said base and constitutes a part of the frame, an upright tool-shaft located outside of said base, a rigid arm on the frame affording a bearing for said shaft, end bearings for the shaft which are adjustable on said arm in a direction endwise of the shaft, and gearing connecting the rotative member of the motor with said tool-shaft.

831,275. APPARATUS FOR HUMIDIFYING AND CLEANSING AIR. John W. Fries, Winston Salem, N. C. Filed April 24, 1902. Serial No. 104,481.

831,284. PROTECTIVE DEVICE FOR VENTILATING-FANS. Robert A. Ilg, Chicago, Ill., assignor of one-half to Theresa Ilg, Chicago, Ill. Filed Feb. 3, 1905. Serial No. 244,028.

831,373. AIR-BRAKE ATTACHMENT. James B. O'Donnell, Freeland, Pa. Filed Nov. 20, 1905. Serial No. 288,190.

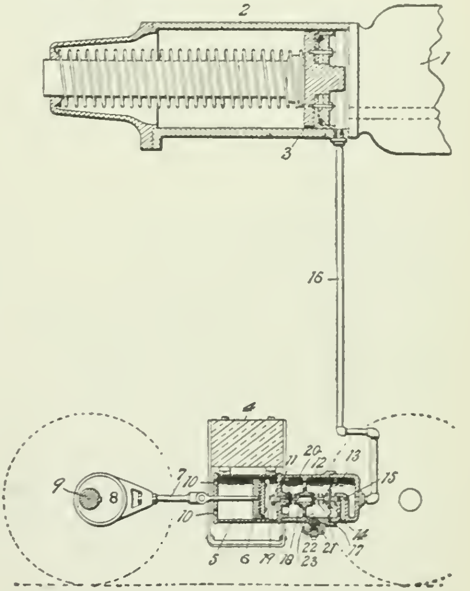
831,418. AUTOMATIC AIR-BRAKE SYSTEM. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Dec. 19, 1903. Serial No. 185,794.

831,540. ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mense assignments, to General Electric Company, a Corporation of New York. Filed Dec. 11, 1903. Serial No. 184,746.

831,677. PRESSURE-REGULATOR. Anthony L. Noone, New York, N. Y. Filed March 22, 1905. Serial No. 251,408.

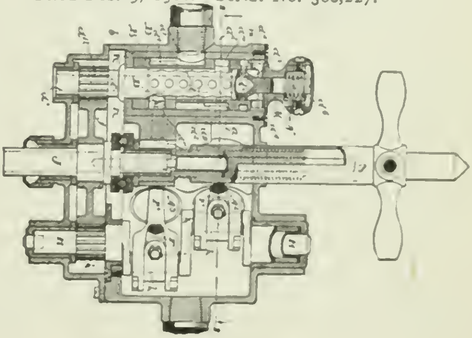
831,739. PRESSURE-REGULATOR. Anthony L. Noone, New York, N. Y. Filed March 22, 1905. Serial No. 251,409.

831,795. HIGH-SPEED BRAKE. William B. Mann, Baltimore, Md., assignor to American Air-Brake Company, a Corporation of New Jersey. Filed March 5, 1903. Renewed Jan. 10, 1906. Serial No. 295,482.



Claim.—In a high-speed brake, the combination of a brake-cylinder, with a relief-valve, a movable member secured thereto, devices exerting a constant force

831,824. VALVE FOR FLUID-PRESSURE MOTORS. Sidney W. Brainard, Cleveland, Ohio, assignor to The Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Filed Feb. 9, 1906. Serial No. 300,227.



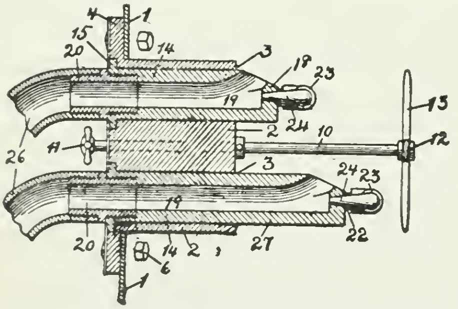
Claim.—In a fluid-pressure motor, the combination of a cylinder, its piston, a crank-shaft, and connections between said crank-shaft and piston, with a rotary valve consisting of two concentric parts, to wit, a tubular shell having an exhaust-port through its wall, and an inlet-port in its surface, and a stem having a longitudinal hole open at one end, and one or more transverse holes through its wall connecting with said longitudinal hole, there being an annular space between the valve-shell and stem, mechanism adjustably connecting said shell and stem, and mechanism transmitting motion from the crank-shaft to said stem.

831,864. RETAINING AND RECHARGING VALVE FOR AIR-BRAKES. Claude B. Harrington, McMechen, W. Va., assignor of one-half to Harry A. Uhler, W. J. Duffy and O. L. Simms, McMechen, W. Va. Filed Sept. 25, 1905. Serial No. 280,096.

831,930. MOTOR OR ENGINE. Charles C. Clark, Corning, N. Y. Filed Sept. 13, 1905. Serial No. 278,327.

Claim.—An engine or motor provided with pneumatic driving means, electrical driving means, and a generator adapted to be operated by air-pressure from the pneumatic driving means and to supply current to said electrical driving means.

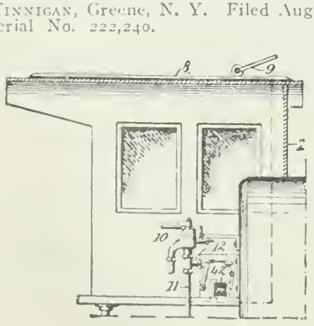
831,970. PNEUMATIC SANDER. John J. Morgan, Baltimore, Md., assignor to John C. Hooper and Thomas M. Hanson, Baltimore, Md. Filed June 19, 1906. Serial No. 322,398.



Claim.—A pneumatic sander comprising a sand-receptacle; a plurality of sand-distributing devices sustained in said receptacle in different horizontal planes and air-tubes in the receptacle and also arranged in different horizontal planes.

832,038. PNEUMATIC VALVE. Hampus A. Carlson, Bridgeport, Conn. Filed April 26, 1906. Serial No. 313,897.

832,306. PNEUMATIC BRAKE-VALVE. George P. Finnigan, Greene, N. Y. Filed Aug. 26, 1904. Serial No. 222,240.

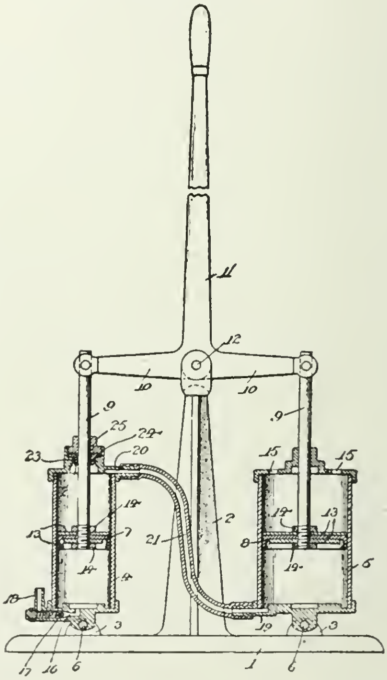


Claim.—In a pneumatic brake-valve, the combination of a hollow pneumatic member provided with an opening, a disk of glass disposed adjacent to said opening and having a convex conformity for the purpose of resisting air-pressure, and means for automatically breaking said disk so as to allow the free passage of air through said opening.

832,374. MOUTHPIECE FOR PNEUMATIC TEAT-CUPS. Alexander Gillies, Geelong, Victoria, Australia. Filed March 22, 1906. Serial No. 307,454.

832,375. PNEUMATIC HEEL-CUSHION. William L. Gordon, Deal, N. J. Filed Dec. 13, 1905. Serial No. 291,562.

382,567. COMPOUND AIR-PUMP. Howard Wixon, Chicago, Ill., assignor to Imperial Brass Manufacturing Company, Chicago, Ill. Filed April 13, 1905. Serial No. 255,291.



Claim.—A compound pump comprising high and low pressure cylinders having inlets at adjacent ends and outlets at the opposite adjacent ends and having an unobstructed passage leading from the outlet end of the low-pressure cylinder to the inlet end of the high-pressure cylinder, and one-way yielding, cupped pistons in said cylinders connected to shift simultaneously in opposite directions, substantially as described.

832,673. PEDAL ATTACHMENT FOR PNEUMATICALLY-OPERATED INSTRUMENTS. Nelson D. Hosley, Meriden, Conn., assignor to The Wilcox & White Co., Meriden, Conn., a Corporation. Filed Sept. 14, 1905. Serial No. 278,410.

832,768. ELECTRIFIER FOR TREATING AIR OR OTHER GAS. James H. Bridge, Philadelphia, Pa. Filed May 25, 1906. Serial No. 318,643.

832,780. FLUID-PRESSURE-ACTUATED MECHANISM FOR CONTROLLING GATES, VALVES, &c. George A. Cutter, Nashua, N. H., assignor to Improved Paper Machinery Company, Castine, Me., and Nashua, N. H., a Corporation of Maine. Filed Feb. 14, 1903. Serial No. 143,339.

832,783. COMPRESSION OF ELASTIC FLUIDS. Sebastian Z. de Ferranti, London, England. Filed Oct. 19, 1903. Serial No. 177,703.

Claim.—An elastic-fluid compressor employing a liquid as the medium of compression, comprising means for giving the liquid velocity, a plurality of fixed tubes or ducts receiving the liquid from such means through which the elastic fluid is compressed successively under pressure by said liquid and a means which said tubes connect for receiving the discharge therefrom.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

JANUARY, 1907.

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THE RAISING OF THE BAVARIAN

The use of compressed air in raising stranded vessels was inaugurated for the first time in the case of the 12,000 ton Allan Liner "Bavarian," which ran on Wye Rock thirty-eight miles from Quebec on the night of November 3, 1905. Almost every method known to wreckers for saving the vessel was tried and found wanting, and over $100,000 was spent in unsuccessful attempts to raise the great vessel from the Pinnacle Rock upon which she was stranded.

Through the courtesy of the North American Wrecking Company, which had charge of the raising of the vessel, we are enabled to present a description of the work, together with photographs and drawings.

The greater part of the credit for the success of the undertaking belongs to two young engineers, Mr. Robert O. King and Mr. William W. Wotherspoon. Mr. Wotherspoon remembered that Mr. King had asked him at one time how a caisson sunk in the river for the purpose of building inside of it the foundation for a pier differed from a ship without a bottom. He recalled that Mr. King remarked that he believed water could be expelled from a wreck in the same way that it was forced from a caisson and that he was convinced that the "Bavarian" could be floated by using compressed air to force the water from her hold. The two engineers discussed the matter and finally decided to take a party to visit the ship. This was done on June 27. After a careful examination of the ship it was decided that the "Bavarian" could be floated by means of the compressed air method, and the young engineers made up their minds to bid for the salvage of the vessel, which was estimated to be worth approximately $1,000,000.

Both men experienced considerable difficulty in securing the backing of men prominent in the scientific and financial world. One of the first to approve of the plan was Judge Charles F. MacLean, of the New York Supreme Court. Later the plans were submitted to Mr. W. G. Rainsford and Captain Thomas C. MacLean, U. S. N., who both agreed with Judge MacLean as to their feasibility.

It was deemed desirable to interest Canadian capital, and when a company was organized to carry out the undertaking, it included Messrs. Charles R. Hosmer, of the Canadian Pacific Railway Company; Thomas J. Drummond, of Montreal; W. E. D. Stokes, W. G. Rainsford, James B. Brady, Jacob Rubine, John A. MacDonald, J. A. Richard, William Koerper, Charles F. MacLean, of New York, and John W. MacLean, of Utica, N. Y. Capital was furnished by these men, and the two engineers were told to go ahead with their plans.

Mr. Wotherspoon, who was to have entire charge of the work up the bulwarks of the vessel, set about obtaining his crew. He had a close acquaintance with that remarkable class of men who make it their business to work in compressed air and who are commonly known as "sand hogs." He therefore collected his crew with great expedition, many of the "sand hogs" and mechanics being engaged actually as they came off shift from the different tunnels in New York.

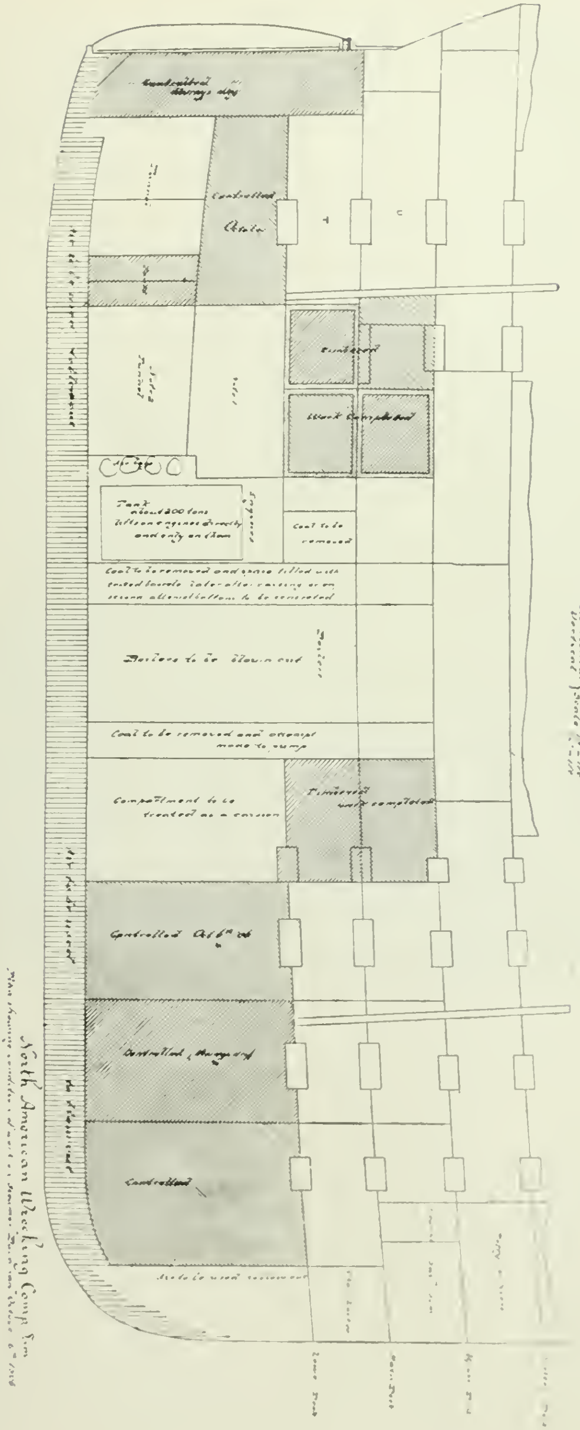
Within thirty days these men, together with thirty more hired in Montreal and vicinity, and the air compressing plant, were taken by tugs from Quebec to the wrecked steamer. It took but a few hours to set up the machinery on deck, and the men who had been brought from New York looked the "Bavarian" over. One of these men was Richard Creedon, a tunnel worker, who was blown through the roof of the East River tunnel by the air pressure and who finally appeared on the surface of the river swimming for the nearest pier.

STEAMER "BAVARIAN" AS SHE APPEARED BEFORE BEING FLOATED.

Examination had shown that the "Bavarian's" bottom amidships was in a very ragged condition. The plating had been torn by the jagged rocks, and it was impossible to patch it. The holes were so large that it would have been useless to try to pump the water out, so the preparations to force it out through the openings of the bottom were hurried forward.

All the ship's compartments were made as nearly air tight as possible. The hatches were closed by plating, which was simply laid under the hatch combing so that when the air pressure was applied the covers would be held in place. Air locks were placed on the compartments which had filled with water. As the air was forced in the water rapidly receded, and the workmen were able to stop the leaks with temporary plating.

One of the most difficult leaks to stop was in the fourth peak tank, which, in the "Bavarian," is a large ballast tank of about 115 tons capacity. An air lock was not placed on this tank, but the manhole was put in place,



ROUGH SECTIONAL PLAN OF STEAMER "BAVARIAN," SHOWING WHERE CAISSONS WERE BUILT; HOW THE TIMBERING WAS CONSTRUCTED AND AIR PRESSURE APPLIED FOR FLOTATION.

and the air pressure applied. When the water had been driven out until the bottom was within a few feet of the surface, the manhole was taken off quickly, and the superintendent and a "sand hog" hurriedly dropped through it. The manhole cover was put on and the air applied. This time the water was forced to the bottom, and the workmen closed the leak so completely that they were able to leave the tank at their leisure.

Judge MacLean and Mrs. MacLean had boarded the ship a few days before the final touches were put on the work. It had been planned to float the vessel on November 15, on which day it was expected there would be a normally high tide, but instead a storm came on which caused a very low tide, and the floating of the ship had to be postponed. It was during this wait that the strain on the mens' nerves was most apparent. Some of the "sand hogs" and the Italians who had been hired to take coal out of the bunkers began to complain. They reminded each other that there was seven fathoms of water off the rock on all sides and that if the ship should turn turtle as soon as she floated off it would be pretty serious for all on board.

In this emergency the presence of Judge and Mrs. MacLean, of New York, proved fortunate. The weather had been very inclement, and it had been suggested that perhaps it would be better for her and Judge MacLean to go ashore before the floating of the ship. But Mrs. MacLean refused to leave the "Bavarian" until the vessel was tied to her pier in Quebec. She went among the frightened men and reassured them by her composure. It is said by those who were there that many of the workmen would undoubtedly have mutinied and gone ashore if they had not been ashamed to show the white feather when a woman remained on the ship.

There was a gale blowing on November 16 and an indication of an unusually high tide. Owing to the bad weather the tugs which had been lying alongside had dropped down the river to a more sheltered position. As the tide rose the air compressors were set to work and the full power of the plant used in forcing air into the holds of the ship. Suddenly there

GROUP OF ENGINEERS IN CHARGE OF THE RAISING OF THE "BAVARIAN."
TOP ROW (from left to right)—MESSRS. CASHMAN, KLOUS, MURPHRE AND STEELE.
BOTTOM ROW (from left to right)—MESSRS. LEE, BAKER AND WOTHERSPOON.

was a movement in the great vessel as she lifted herself from the rocks, and a cheer went up from those on board. Five minutes later the "Bavarian" floated clear of Wye Rock in sixty feet of water. After the first few minutes all apprehension that the vessel might turn turtle or that the air pressure would not hold the water back was dispelled. The "Bavarian" floated on almost even keel and was soon in the tow of tugs on her way to Quebec.

Estimates show that the cost of salving the "Bavarian," in accordance with the plan of Mr. Wotherspoon and Mr. King, was less than one-fourth the amount expended by those who attempted unsuccessfully to raise the vessel by the use of old wrecking methods. Only $30,000 was spent, and if the salvage is half the value of the vessel, which is the law, the prize is worth nearly $500,000 to those who risked their capital in an untried scheme.

Among those who greatly assisted in the work should be mentioned Mr. S. B. McQuade, of the Ingersoll-Rand Co., who acted as expert in the compressed air work and who made several trips to the wreck, rendering valuable advice. Some seventy men were employed on the ship during the work. As may be imagined from studying the circumstances, everything in regard to the operation had to be calculated with mathematical accuracy. When work was begun by the company on September 9 it was first necessary to clean out the holds and lighten the ship of everything movable. It was found that considerable grain, cheese, pulpwood, coal and other material had been left in some of the holds, and the cleaning-out process occupied some time. Then it was necessary to solidly timber several of the compartments and render air tight the section beneath the lower deck amidships (lower hold No. 4), which was to be used as a caisson. The timbering above the caisson compartments was particularly fine, extending as far as the upper deck. This was necessary as, when the air pressure was applied, the whole weight of the ship would depend upon the upper decks. A wooden tank of about 200 tons was also built directly beneath the engines, and this being made absolutely air tight, the weight of the engines rested upon it alone. Air bags and tested barrels were secured in the bunkers and stoke hole, the whole lifting power of the air being so calculated as not to materially throw the ship out of trim when she should rise.

Exactly what will be done with the "Bavarian" in her new lease of life has not yet been decided. If she is dry docked at Quebec it will be a tight squeeze, as the entrance to the dock is only 59 feet 6 inches wide and the ship is 59 feet 3 inches beam. She may be brought to New York or taken to Halifax, or perhaps not permanently repaired until she can be taken across the Atlantic to her builders' yards. It is generally expected, however, that she will eventually resume service in the Allan Line. The future program of the North American Wrecking Company has also not been completed. The company, which has its head offices at 16 East Forty-second street, New York, is a Canadian corporation, with Messrs. T. J. Drummond (of Montreal), president; W. E. D. Stokes (of New York), vice-president, and W. G. Rainsford (of New York), treasurer.

THE ANTECOOLER, THE INTERCOOLER AND THE AFTERCOOLER

By Frank Richards, M. Am. Soc. M. E.

There is one thing to be said for these several coolers which cannot be said for any other of the products of compressed air machinery manufacturers, and that is that they do their work for nothing. Almost everything that is gotten up to do some thing costs something for the working of it. It requires either power to drive it or material to consume, or both; and then in figuring the cost of the product this power cost or material cost has to be deducted. With the coolers there is nothing required of either power or material. There can be absolutely no operative charge against the most important and effective of them, the intercooler, except for the water that flows through it, and that can't cost anything, because the water is just as usable for any purpose after as before; and yet the good work which the intercooler does is indisputable, is easily computable and is of great actual value.

The intercooler being such a bargain, I am much in favor of employing it wherever practicable, and it certainly ought to be employed much more extensively than at present. An antecooler would work on the same principle as the intercooler and just as cheaply, and there are many cases where it could be employed with profit, especially in the summer, and in all cases where very cold water is available; and it is not at all certain that the makers of intercoolers and aftercoolers should not make and advertise and sell antecoolers also.

The intercooler, of course, implies the compound or two-stage compressor, and this, up to the undebatable pressures, is quite apt to be regarded as an unprofitable refinement or a costly complication. The status of a compressor to the intending purchaser, and also to the salesman, as to whether it should be single stage or two stage, should be precisely the same as whether it should be a 20-inch or a 24-inch machine, the ultimate question in either case being as to which will be the machine to do what we want it to do, and to do it most cheaply and most satisfactorily.

It is more or less of an open question as to what air pressures should employ two-stage compression and as to the upper limit of single-stage compression. Coming right near home we find some interesting air-compressing plants employed upon the New York tunnel work. In these plants we generally find two different systems employed and two entirely separate and different sets of apparatus; one for "high" and the other for "low" pressure, the former going up to 125 pounds and the other never expected to go above 50 pounds. For the high-pressure service two-stage compressors are, of course, employed without question, but for the low pressure there is single compression, and here might come in the question as to whether two stage should not go down to that also. In the service here referred to, the question does not really apply, because, as a matter of fact, the low-pressure compressors work most of the time at 20 to 30 pounds, but there are many places where 50 pounds is a pressure to be constantly maintained, and then the case is worth looking into.

Say that we want to constantly deliver the air at 50 pounds in any ordinary case, taking it in at 60 degrees and compressing in a single cylinder. We will take a 30-inch diameter cylinder at 400 feet piston speed. The free air capacity will be 1,963 cubic feet per minute, the mean resistance for the compression stroke—adiabatic compression—will be 27.39 pounds, and the horse power required will be 234.67. It is not necessary to say anything here about the friction of the machine, since it will be ignored equally in all the cases cited; and also the temperature at which the air is delivered does not interest us, so that the given volume of free air goes through.

Now, suppose we try two-stage compression in the case, with an efficient intercooler, working for nothing, between the stages. The diameter of the first cylinder and the piston speed is the same as before, giving an equal free air capacity. We compress in the first cylinder to 25 pounds, this pressure being fixed by the relative capacities of the first and the second cylinders and remaining constant, regardless of the final or delivery pressure. The mean resistance—adiabatic compression—will be 17.01 pounds, and the horse-power will be 145.74.

If the air is then cooled to the original temperature, the pressure being maintained, the reduced volume will be inversely as the increased absolute pressure—40:15 or 8:3, and for the second cylinder the piston area, with the same stroke, should be at this ratio, which would make it 18⅜-inch diameter. The M. E. P. for the second compression from 25 to 50 pounds would be 20.84 pounds, and the horse power would be 66.99, say 67, making the total 145.74 + 67 = 212.74, which is apparently a saving of 9 per cent. As the intercooler would probably not cool the air quite to the original temperature, and as the friction of the machine as a whole would be slightly increased, the saving would probably be not more than 5 per cent. at the best, so that in compressing to 50 pounds it is doubtful whether two-stage compression with intercooling would not "cost as much as it came to."

It happens that the great majority of air compressors in use work at higher pressures than this, say from 75 to 90 pounds, this being the working pressure for rock drills and for most of the air-operated tools of the shops. It is important, therefore, that for the class of compressors most numerously employed the minute economies be investigated and that economies not absolutely minute be adopted by those who work for profit.

With the same cylinder data as before, 30 inch diameter and 400 feet piston speed, the M. E. P. in compressing adiabatically to 75 pounds will be 35.23 pounds and the horse power 301.85.

Say, now, that we try two-stage compression on the same job, compressing in the first cylinder to 30 pounds. The M. E. P. for this compression, adiabatic, will be 19.4 pounds, and the horse power 166.3. For the second cylinder the diameter would be 17.32, the M. E. P. 34.56, and the horse power 98.7, making the total horse power 166.3. + 98.7 = 265. Here the difference is a little over 12 per cent., which is evidently worth saving, and if you don't save all of it you save a couple of years of savings bank interest anyway, all in a second or less. The percentage of power cost of single-stage over two-stage compression, with perfect intercooling in this case, is nearly 14 per cent.

To compress to 90 pounds, single stage, the M. E. P.—adiabatic—would be 39.18 pounds and the horse power 335.71. Using the same two-stage cylinders as before and compressing to 90 pounds, the work of the low-pressure cylinder would be precisely the same as before and the horse power the same, 166.3. For the high-pressure cylinder, compressing from 30 to 90 pounds, the M. E. P. would be 43.41 pounds, and the horse power 123.97, making the total horse power 166.3 + 123.97 = 290.27, or nearly 14 per cent. below that for single-stage compression, while in terms of the two-stage compression the excess of horse power for the single stage would be more than 15½ per cent.

The gain here, all for nothing, would seem to be beyond question, and this for the common every-day working pressures. The adoption of the two-stage compressor would seem to be imperative for any permanent plant which was expected to do its work as cheaply as possible. If a man will not take such profits as this, which offer to keep dropping into his pocket every minute his compressor is in operation and with nothing going out, you don't have to even oil an intercooler—it can't be profit that he really is looking for.

With the intercooler treating its employer so generously, the employer should not be niggardly. The intercooler should be made of liberal capacity, so that it can do its work leisurely and thoroughly, and customers should not be educated to expect to get the intercooler for next to nothing because its work costs nothing.

The intercooler does more than reduce the horse power required for compression. It does much to remove what is, in some cases, the most serious objection to the employment of compressed air. Dry air can't freeze up, and the intercooler helps to dry the air. This is the special function of the aftercooler. There is practically no such thing as "dry" air, and the dryness of air is always comparative. When the air is at its highest pressure, which it is just when leaving the compressor, if it can then also be reduced to its lowest temperature, its moisture-carrying capacity will be at the minimum. It will be wet air; so wet that the water will be dropping out of it. The water should here be given every chance to drop out, and when further along its pressure falls, and its temperature rises, this same air, without giving up another drop of the moisture that is in it, becomes "dry air," and remains dry air while in use.

If the air ,with the heat of the final compression in it, is not cooled, and thus dried before it starts on its journey through the pipes, it will begin dropping the water out of it as it goes along, and it will be "wet air" instead of dry air all the way. In freezing weather in out-of-door work, as in quarries, the moisture will freeze, little by little, to the interior of the pipe and soon choke it up, or some of the ice will be carried along to an elbow or to some depression or pocket and form a solid obstruction there. One peculiarity about ice is that when two pieces or particles come together, no matter what the temperature surrounding them, and without being forcibly pressed together, they freeze together solid. There are always meeting-places for the ice particles in the pipes and passages, and there they solidify and trouble follows. When the moisture is not in the air the air can't freeze up, and nothing can be choked by ice. In weather that is not freezing, the moisture which is in excess still makes constant trouble. It collects in low places and then it starts in a body, and we have water-hammer and leaky joints. The changes in temperature in the pipes from the alternate hot and cold condition of their contents when the air is not cooled at the compressor, make expansion and contraction strains in the pipes, which result in leaks, if not breakages, of the line.

One most serious effect not generally realized in the rock drills or other tools or machines which the air is used to drive is in the interference with the lubrication. It is generally understood that oil and water will not mix, but all the consequences of this are not realized. It means that whether oil or water first occupy the surfaces (the internal surfaces) of a machine, the other is effectually excluded from those surfaces, so that when the moisture of saturated air condenses upon surfaces requiring lubrication, the oil can't get at those surfaces, and lubrication is defeated. The surfaces wear or cut, and while they are working the drills take more power to drive them on account of the abnormal friction.

All these troubles with uncooled air are matters of repeated and constant experience, and the beneficent effects of immediate and thorough aftercooling and drainage of the air at the compressor are also matters of evidence and record. Even though the work of the aftercooler can't be paid for—there is no place to spend the money on it after you have it—its service cannot be dispensed with without constant loss. Money is often lost by unwise purchases, but in this case the loss would be in *not* buying the aftercooler.

THE LATTA-MARTIN PNEUMATIC DISPLACEMENT PUMP

The compressed air displacement pump is coming more and more into general favor owing to the fact that it is absolutely automatic in its operation and will operate efficiently at almost any distance from the source of power, thus permitting of several pumps being installed in different places and operated from a central compressed air power plant. Among other advantages possessed by this type of pump should be mentioned the fact that it will handle muddy or gritty water without in any way impairing its efficiency, owing to the fact that it possesses no pistons, plungers, stuffing boxes, glands or other parts in its mechanism which might be injured thereby.

In addition to the advantages enumerated above, the Latta-Martin Pneumatic Displacement Pump possesses some qualities which place it in advance of other types of compressed air displacement pumps. Chief among these is the fact that it contains no floats, which have always been a source of trouble in other pumps of this type.

The cross-sectional view shown in Fig. 1 illustrates very clearly the details of the construction and operation of the Latta-Martin Pump. In general the pump consists of two plain cylinders with a valve mechanism attached to their heads. This mechanism comprises a main valve and an auxiliary valve, shown in detail sections, each operated by the air pistons, and an oscillating slide valve. A, under the main valve. B and B are plain covered copper buckets which, when the pump is installed, become and remain full of water. Particular attention is called to the fact that these are not floats, the buckets being suspended on steel rods connected to steel levers which operate the oscillating slide valve A. The buckets are enclosed in galvanized iron housings, C and C, which are connected to a header on top of the cylinders by pipes E and E.

The operation of the pump is as follows: When it is submerged in water, the cylinders at once fill by gravity through the foot valves, R and R. The main valve mechanism, as shown in the detail, operates the slide valve A_2, and opens and exhausts at proper intervals the live air ports J and K. For instance, in starting the pump live air travels down through the air inlet S into the open port J and into the left hand cylinder, which is full of water. This compressed air forces the water, by displacement, down and out through the discharge O, up through the check valve P, and into the water main at Q. When the water has been forced from the left hand cylinder down to a level slightly above the opening O, the bucket B, which is full of water, is supported only in a column of air, while the bucket in the opposite cylinder on the other end of the lever is immersed in water and therefore weighs almost nothing. The bucket in the left hand cylinder then becomes a dead weight, pulls down the rod and lever to which it is attached and operates the slide valve A, which throws live air through port F and F′ to one end of the auxiliary piston L. At the same time A opens an exhaust port from the opposite end of auxiliary piston L, through port G′. The piston L moves its slide valve, which throws live air through port I and I′ to one end of the piston in the main valve M. At the same time it opens exhaust port H and H′ from the opposite end of the main piston in M. The latter carries with it the slide valve A-2, which crosses the port J, and exhausts the compressed air, which has done its work in the left hand cylinder, and throws live air into the right hand cylinder through the port K, while the exhaust from the other cylinder passes out.

through the exhaust fittings T and T'. While air has been forcing water from the right hand cylinder the left hand cylinder has been exhausted and has become full of water by gravity through the foot valve R, the operation taking place alternately between each cylinder, giving a continuous flow of water.

Attention is called to the accessibility of the valve mechanism for repairs. By removing the bolts around the header on top of the cylinders, as shown in Fig. 1, the entire valve mechanism, together with housings and buckets, may be removed without disconnecting any water fittings. It will be appreciated that there is no possibility of the pump getting on dead center and that it is capable of handling the muddiest and grittiest water, as all valves, including the oscillating slide valve, never come in contact with the water. The absence of wear inside the cylinders is also to be noted, where there are no working parts except the buckets, and these do not touch or come in contact with the housings within which they operate. Long life is insured from the fact that the travel of the buckets is but 2 inches, travel of main slide valve 2 inches, auxiliary valve 1 inch and oscillating slide valve ½ inch per stroke. At the highest speed at which these pumps are operated this stroke does not take place over six times per minute.

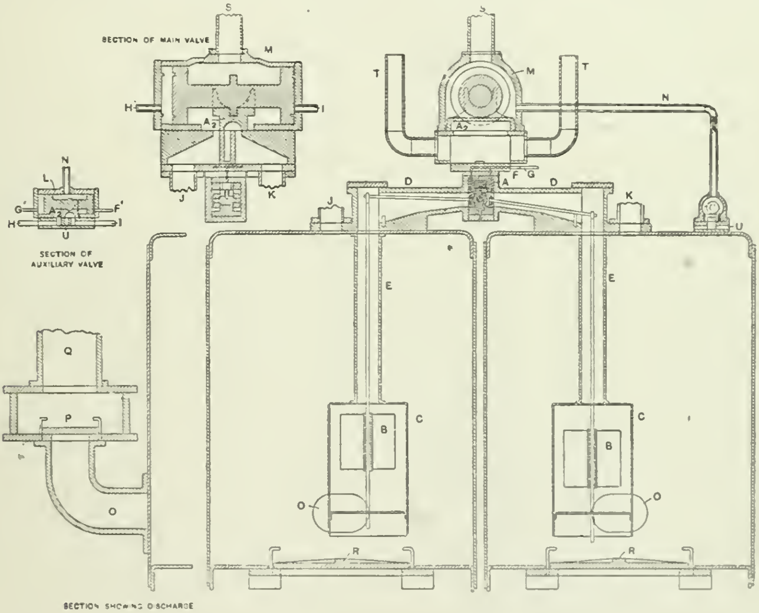


FIG. 1—SECTIONAL VIEW OF LATTA-MARTIN PNEUMATIC DISPLACEMENT PUMP.

An installation of such an equipment has been made for the water works system of the city of Hickory, N. C. With it the city is pumping its water supply from the South Fork River, at a distance of three miles from the power plant, which is located inside the city limits on the line of the railroad, using a 3-inch transmission line, and the displacement pump at the river forces back to the city a 10-inch stream of water against a total head of 320 feet. This installation gives one of the longest and most severe tests of transmitting air for pumping purposes that has ever been made. It has now been in operation for about a year and is giving most satisfactory results. By it the city has been able to eliminate establishing a pumping plant at the river and so save the cartage of fuel to that point and the necessity of keeping a machinist at the river. The water system is now arranged so that the subsiding and filter basins and clear water well are all located at the power plant inside the city limits, requiring only the services of one day man and one night man to run the entire plant.

The pneumatic displacement pumps are manufactured by the Latta & Martin Pump Company, Hickory, N. C. The eight standard sizes range in capacity from 25 gallons per minute, under a pressure of 150 pounds, to 1500 gallons per minute at 90 pounds. The smallest has cylinders 14 inches in diameter by 36 inches high, and the largest 48 inches in diameter by 60 inches high. The pumps are made to order, for any capacity and any pressure.

CLEARANCE IN A COMPRESSOR, AND ITS RELATION TO VOLUMETRIC EFFICIENCY

By D. W. Hering.

In any list of the merits and demerits of different types of compressors, one of the defects is waste space or clearance. By this is meant the space between the piston at the end of the stroke and the tank or pipes containing the air at its final pressure. It consists of a short space between the piston and the cylinder head when the stroke is completed, and a small necessary space required for the placing and working of the valves. Small as this space is in fact, being in well constructed compressors from one-fifth of one per cent. to one per cent. of the entire volume of the cylinder, it interferes somewhat with the volumetric efficiency of the compressor, and the more so if high pressure is required.

In machines of inferior construction the clearance is larger and the efficiency is correspondingly diminished. If the piston must nearly complete its traverse before the requisite pressure is reached, it is evident that the portion of the compressed air in the clearance space will be a considerable part of the whole, and only the remainder will be delivered to the reservoir. Effective cooling of the air within the compressor cylinder aggravates this evil, for the colder the air the smaller will be the total volume when the maximum compression in the cylinder is accomplished, while the volume of air in the clearance is not diminished, and therefore this is a larger proportion of the whole when cold than when hot. It is plain, too, that a large clearance space might result in no air being forced out of the compressor cylinder even with moderate compression. In cylinders of ordinary proportions, compressing to seventy-five pounds gauge, if the space between the piston and the head at the end of the stroke is one-sixteenth of an inch, the clearance loss of volume is from one to five per cent. of the air when compressed.* The only real objection to the clearance space, however, is this of diminished quantity of air delivered, and not, as has been sometimes supposed, a waste of power, for the work expended upon the air in the clearance is returned by it in expanding against the receding piston. In an extreme case, where the maximum pressure would be reached just at the end of the stroke and no air would be delivered, the re-expanding air would return all the power applied except that necessary to overcome the frictional and thermal losses, and the machine might run along continuously with little power applied, with considerable compression within the cylinder, and with nothing accomplished. With some cooling of the cylinder, the air in expanding might fall in temperature below that of the external air and so, in some degree, cool the incoming air, which would be an advantage by lessening the work of compression.

When the piston has moved to its furthest position in compressing and expelling the air within the cylinder, the clearance space will contain air at the maximum pressure. Upon the return of the piston the air in the clearance space expands until its pressure is equal to that of the external air or slightly less, before more air will enter the cylinder. The ratio, in hundredths, of the volume of the clearance space to that swept through by the piston in moving from one end of the cylinder to the other, expresses the amount of clearance in per cent. In discussing this subject we may follow, in part at least, the method of Von Ihering. **

Calling the volume of the clearance space V_c, that of the piston displacement V_a, and the clearance C, we have $C = \frac{V_c}{V_a}$, or $V_c = CV_a$ ....(A)

In the accompanying diagram (Fig. 1), taking as usual, horizontal distances to represent volumes, and vertical, pressures,

Fig. 1.

Let $AE = V_a$ = volume of piston stroke.

$EM = CV_a$ = volume of clearance,

$FM = V'_c$ = volume to which air in clearance space expands as piston returns towards A, when pressure falls to P_a.

$AB = P_a$ = pressure of the atmosphere,

$ED = P_1$ = maximum pressure in clearance.

$AF = V_x$ = volume of air drawn into cylinder.

Then BCC′ represents the compression curve, DG the expansion curve from a maximum pressure of ED in clearance, and D′G′ the expansion curve if the maximum pressure in clearance were equal to ED′. The higher the pressure of expulsion, *i. e.*, the ordinate of C or D, the nearer G approrches B, or V_x approaches zero. Further, when the piston begins to recede, let V_c be the volume of air in the clearance space, P_1 its pressure, T_1 its temperature; and at the end of its expansion suppose V_c has changed to V'_c, P_1 to P_a, and T_1 to T'_1.

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*W. L. Saunders.

**Die Gablaese, Part II, Chap. IV.

The volume to which the air will expand will depend upon whether the expansion is isothermal, *i. e.,* with no change of temperature; or adiabatic, *i. e.,* with no gain or loss of heat; or intermediate between these, which we call polytropic.

(1) Suppose the expansion to be isothermal. Then $T_1 = T'_1$, and by Boyle's law the product of pressure and volume at the beginning of expansion equals the product of volume and pressure at the end, or $P_1 V_c = P_a V'_c$, whence, if we call the ratio of compression $\frac{P_1}{P_a} = r$, we have $V_c' = \frac{P_1}{P_a} V_c = rCV_a$ ....(B)

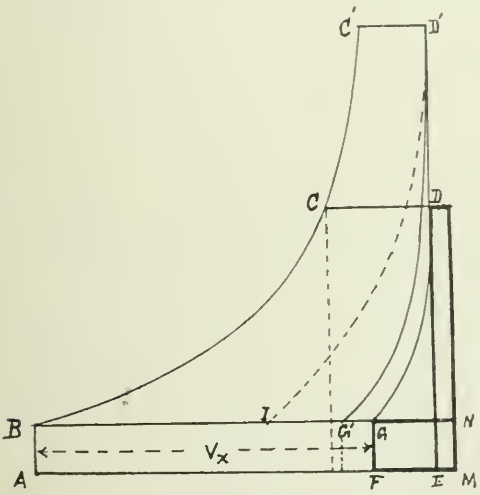


FIG. I.

The volume of new air that will be drawn into the cylinder is the difference between V_a and V'_c, which we may call V_x; then

Vol. of piston sweep	+	Vol. of clearance	=	Vol. to which air in clearance expands	+	New air to fill cylinder

$$V_a + CV_a = V'_c + V_x$$

Whence, $V_x = V_a (1 + C) V_a - V'_c$ which becomes, by introducing the value of V'_c from equation (B),

$$V_x = V_a\ (1 + C - rC) = V_a\ \left[1 - C\,(r - 1)\right] \text{ ....(C)}$$

The *volumetric efficiency* is the ratio which the volume of air admitted at each stroke bears to the actual volume traced by the piston, or $\frac{V_x}{V_a}$. Calling this ratio E_v, we have from equation (C)

$$E_v = 1 - C\,(r - 1) \text{ ....(D)}$$

E_v may be anything from unity, which would be its value if there were no clearance and no leakage with free admission of air, to zero, when no air would be driven from the compressor into receivers, at the maximum pressure. In this latter case the air would re-expand so as just to fill the compressor cylinder when its pressure fell to that of the external air. No new air would be taken in, or $V_x = O$. From equation (D) we see that this would be the case, or $E_v = O$, if $1 - C\,(r - 1) = O$, or $C = \frac{1}{r - 1}$

and $r = \frac{1 + C}{C} = \frac{1}{C} + 1$..................(E)

From this equation we may see at what ratio of compression, with a given clearance C, a compressor will cease to deliver air, and from equation (D) we may determine the ratio of compression that will result in delivering any stated proportion of air. For instance, if $C = .02$, equation (E) shows that $r = 51$, and if $C = .05$, $r = 21$, and in this latter case it would be useless with this compressor to try to get air at a pressure of 21 atmospheres, or 294 pounds gauge pressure.

To find at what ratio of compression a definite fractional part of the volume of the piston sweep would be delivered at each stroke, put E_v equal to this fraction, in equation (D) and solve for r. Suppose, for example, that with a clearance of five per cent. we wish to know how high a pressure we could maintain with a volumetric efficiency of fifty per cent. Here $C = .05$, $E_v = \frac{1}{2}$ and equation (D) gives $r = 11$; *i. e.,* the air may be compressed eleven fold, or to 147 pounds gauge pressure if it is initially at standard pressure of 14.7 pounds per square inch. In such case it would require two strokes of the piston for every cylinder full of free air delivered under pressure, and the process would be correspondingly slow.

If the ratio of compression, r, and the clearance C, are both determined in advance, then equation (D) gives at once the volumetric efficiency. With a high grade machine suppose the clearance is one-half of one per cent. : *i. e.* $C = \frac{1}{200}$, and the air is to be compressed to 14.6 atmospheres, *i. e.*, $r = 14.6$, or the final pressure is to be 200 pounds gauge; equation (D) gives $E_v = .932$ or *93.2 %*.

These equations and results are on the supposition that expansion in the cylinder is isothermal. As the air expanding against pressure would fall in temperature, the expansion could not be isothermal unless the air underwent some heating while expanding. But in practice not only does this not occur, but with a water jacketed cylinder, whatever effect the jacket has in cooling applies on the expansion side of the piston as well as on the compression side.

(2) Suppose the expansion to be adiabatic: We may derive similar formulas. Using the same notation as before,
$P_1 \ V_c = RT_1$ and $P_a \ V'_c = RT'_1$, where R is Regnault's constant whose value is 53.2 if pressure is pounds per square foot, volume is cubic feet, and temperature is in Fahrenheit degrees. Of course where *ratios* of pressures or volumes or temperatures are concerned it does not matter in what units they are expressed. From these two equations we have
$\frac{P_1 V_c}{P_a V'_c} = \frac{T_1}{T'_1}$ and $V'_c = \frac{P_1}{P_a} V_c \frac{T'_1}{T_1}$, in which
$V_c = CV_a$ From the thermodynamics of gases
$\frac{T_1'}{T_1} = \left(\frac{P_a}{P_1}\right)^{1 - \frac{1}{k}}$ in which k is the adiabatic exponent *1.41*; hence $V'_c = CV_a \left(\frac{P_1}{P_a}\right)^{\frac{1}{k}}$
$= CV_a \, r^{0.7092}$

Also, as before, $V_a + CV_a = V'_c + V_x$

$$\text{whence } V_x = (1 + C) \ V_a - V'_c$$
$$= (1 + C) \ V_a - CV_a \, r^{0.7092}$$

$$\text{or } V_x = V_a \left[1 - C\left(r^{\frac{1}{k}} - 1\right)\right] \ldots\ldots \text{(F)}$$

This gives for volumetric efficiency,

$$E_v = \frac{V_x}{V_a} = 1 - C\left(r^{\frac{1}{k}} - 1\right) \ldots\ldots\ldots\ldots \text{(G)}$$

The values of E_v approaches unity, its highest possible value, as C and r become smaller. E_v become zero if

$$1 - C\left(r^{\frac{1}{k}} - 1\right) = 0 \quad \text{or} \quad r^{\frac{1}{k}} = \frac{1 + C}{C}$$

$$\text{whence } r = \left(\frac{1 + C}{C}\right)^k \ldots\ldots \ldots\ldots\ldots \text{(H)}$$

The similarity of equations (F), (G), and (H), with equations (C), (D), and (E) is readily apparent. Apply them to the former example, with a clearance of two per cent., equation (H) gives $r = 255.6$ and with $C = .05$, $r = 73.17$ as the limiting ratios of compression at which any air would be forced into a receiver. For the pressure under which this compressor with five per cent. clearance would deliver one-half of the cylinder contents at each stroke, by putting E_v in equation (G) equal to ½, we find $r = 29.3$, which corresponds to a gauge pressure of 416 pounds per square inch. If the compressor has a clearance of only 1-200 part, and the compression is carried to 200 pounds gauge, *i. e.*, $r = 14.6$, the volumetric efficiency shown by equation (G) is $E_v = 0.972$ or 97.2 %. In like manner values could be computed for any per cent. of clearance, or any ratio of compression.

(To be concluded.)

THE EFFICIENCY OF THE TURBINE AIR COMPRESSOR

Some highly interesting results have been obtained with a Rateau air compressor, built at Baden by Messrs. Brown, Boveri & Co. A description of the plant, with the figures obtained on test, is given in a recent issue of the *Schweizerische Bauzeitung.* The compressor in question was designed to supply one cubic metre (35.3 cubic feet) per second, at a pressure of 5 atmospheres, when running at 4,000 turns per minute. Actually it was found necessary to increase the speed to 4,250 turns per minute in order to get the desired pressure, and the discharge was then 1.13 metre per second (2,394 cubic feet per minute). The air passed through the machine was measured by making the compressor draw its supply from a large reservoir. The air entered this through a gauged orifice, the amount passed being deduced from the pressure registered by a water-gauge fitted to the reservoir. The result thus obtained is said to be correct to within 1 per cent. The efficiency was measured in two ways. First, by the ratio of the work theoretically necessary to draw in, compress and deliver the air under the actual conditions of the test, to that actually expended on the compressor shaft. Reckoned in this way, the efficiency was 69.8 per cent. In many practical applications, however, the compressed air is necessarily cooled down to atmospheric pressure again before it is made use of. Hence the efficiency of this compressor has also been reckoned on the basis of the ratio of the work necessary to compress the air isothermally to that actually expended. Thus reckoned, the efficiency amounted to 61.5 per cent.; a figure which, it is asserted, has never been surpassed by a reciprocating compressor in which the measurements have been made with due care. Too commonly in testing reciprocating compressors the quantity of air passed is estimated from the indicator diagram. Tests made by quite independent and competent observers have shown that the error thus made may range between 4 and 10 per cent. When due account is taken of this fact, it is claimed that the turbine compressor is fully as efficient as the best of the reciprocating compressors if the air after compression has to be permitted to cool before it is utilized.

DUPLEX AIR COMPRESSORS

BY TECUMSEH SWIFT.

I am tolerably familiar with "write-ups", and there seems to be a plenty of them, and I understand pretty well the why of them. Just now I am anxious to find out about "write-downs"; what they are for and what is intended to be accomplished by them.

The cut herewith, which I have seen lately in more than one technical journal accompanies and is intended to illustrate and explain a "write-down" of the duplex air compressor. It is a wonder to me in the first place that any one could write such a thing and in the second place that it could appear on the page of a reputable and well-informed journal; but there it is.

I might as well speak straight out what I think about the matter. The article from which the above cut is taken is not signed and nobody apparently is responsible for it, except as the editors endorse it by publication, but it seems to be put out in the supposed interest of builders of air compressors which are not duplex, the assumption apparently being that anything derogatory to the duplex is necessarily an endorsement of the straight line, or any other old machine.

Those who are familiar with the best air compressor practise of the day, do not need to be told that in all the large and more or less permanent installations of air compressors, and in all plants where the best steam economy and the most absolute reliability of service are sought, the air compressors employed are precisely those which are attacked in the article here referred to: Corliss cross compound condensing machines.

Of the 80 air compressors now running day and night upon the tunnel and railroad work in and around New York city, most of them are of this type It has been recently computed—the figures can be produced— that one of these compressors—Corliss cross-compound condensing—in its economy of steam as compared with the steam consumption of Meyer slide valve, straight line compressors, con-

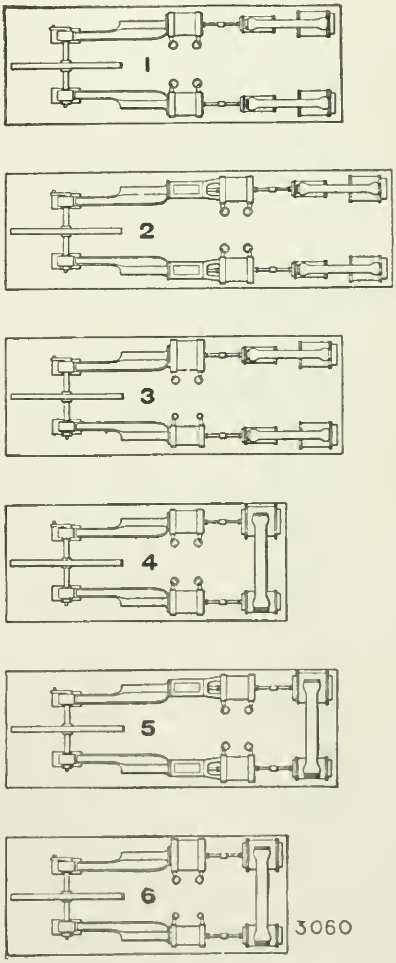


FIG. 1.

siderably more than pays for itself in a single year.

The cut herewith is said to represent the six different types of duplex air compressors with compound air compression. These are:

1. Twin tandem compound air cylinders and twin simple steam cylinders.
2. Twin tandem compound air cylinders and twin tandem compound steam cylinders.
3. Twin tandem compound air cylinders and cross-compound steam cylinders.
4. Cross-compound air cylinders and twin simple steam cylinders.
5. Cross-compound air cylinders and twin tandem compound steam cylinders.
6. Cross-compound air cylinders and cross-compound steam cylinders.

The collection either indicates that the compiler is not accurately formed as to air compressor practise or it must be taken as a fine example of the ingeniously disingenuous. These six different combinations are, of course, all possible, and samples of each may have been built, but we are talking here—or what's the use of talking at all—rather about the actual machines of the present and the immediate future, about machines now to be built and sold; and who would build, or who, sufficiently informed, would buy *duplex* machines with *tandem* compound cylinders either steam or air, four cylinders to do the work of two, or, as in No. 2, eight cylinders to do the work of four. We have to do, therefore, only with No. 4 and No. 6. as representing the now possible machines.

One charge made in all apparent seriousness against the duplex machines is that if any part of a machine is so deranged as to make stoppage necessary, the entire machine must stop. Is not this equally true of all straight line machines? If the steam cylinder gives out the air cylinder can't run. If one connecting rod box heats up and melts the babbitt out, you can't run with the other rod.

The duplex machine is a single machine, as much so as the straight line machine, except that it is usually a larger unit. The duplex machine often represents the capacity of three or four straight line machines, and for probability of stoppage for repairs or replacement, the one is properly only comparable with three or four of the other, instead of with a single one.

Not long ago I was privileged to make a tour of all the compressor plants employed on tunnel and railroad work in and around New York, where the 80—the precise number—of compressors spoken of are running, and not one of these machines was out of order or undergoing repairs. Nearly everyone was running up to or above its full rated capacity, and every one not so running was ready to start at any moment if required.

This talk about the probability of stoppage for breakdown or derangement might well originate with the builders of an inferior line of compressors, it being their familiar experience; but, as a matter of fact, while the work of the air compressor is onerous the standard machines are built to meet the conditions, and breakdowns, derangements and stoppages for repair are much more frequent, and, in the bulk, much more costly for the common straight line than for the high class duplex machines.

"The generally observed friction of the duplex machines," it is said, "exceeds by about 5 per cent. the friction of two machines working separately." I understand that the capacity of the two machines here referred to is equal to that of the one duplex machine. As to the friction of the machines, everybody except the writer of the above knows that precisely the reverse is true. Richard's "Compressed Air" says that the friction of large Corliss duplex machines is often less than 5 per cent., while that of straight line compressors is seldom less than 10 per cent., conclusions deduced from numerous sets of indicator cards and which have gone unchallenged for ten years.

"For any given output of air they are more expensive in first cost and up keep." This, too, is misleading and as to the up-keep untrue. The machine represents a little more expense at the beginning to make a larger profit all along. The larger cost of the compressor is largely offset, anyway, by the smaller boiler cost.

It is not necessary to reproduce here the plans of the straight line compressors which accompanied the others to show how much less floor space is occupied by the straight line machine. These machines are not planted in

Wall Street, but usually where land costs nothing and roofs and floors but little. The habit which the duplex machines have of insisting upon sufficient floor space to make every part of the machine perfectly accessible when in operation, and for getting or taking out any part without disturbing the rest, is one of the best things about them. The straight line machines are crowded together and internally inaccessible enough at the best, and the way in which they consent to be stuck away in dark and dirty corners, inviting contempt and neglect is a most deplorable characteristic. I do not willingly say anything against the straight line machines of any make, for they have been the pioneers and have done excellent work in promoting and establishing the compressed air industries, but the machine of to-day is also to be respected, and certainly deserves to be protected from misleading misrepresentation. It may be well to remember that a "write-down" of any machine is not usually a "write-up" of any other.

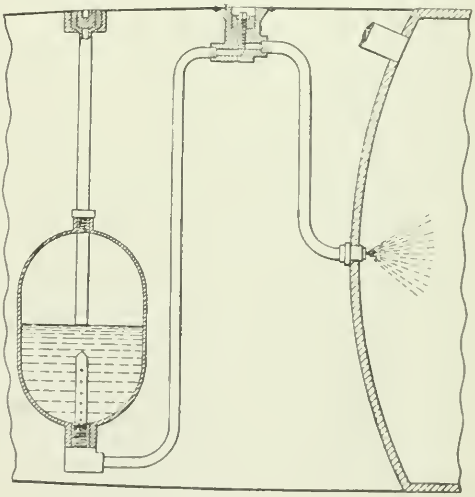
A NEW METHOD RE-HEATING COMPRESSED AIR FOR USE IN TORPEDOES

Re-heating compressed air for the purpose of increasing its volume and so enabling it to do more work than would be possible if it were cold, has been practiced for a number of years. It is only recently, however, that this system has been applied to torpedoes, and this invention, patented by William Horace Sodean, of Newcastle-upon-Tyne, England, and assigned to the W. G. Armstrong, Whitworth & Co., the well known builders of torpedoes, is an improvement over certain former invention of his designed to accomplish the same purpose.

As described in the American Inventor, this device re-heats the compressed air by burning inside the reservoir alcohol, petroleum, or other combustible liquid, thus raising the temperature of the air and consequently increasing the volume which the compressed air will have at a given pressure.

In the practical application of this discovery it was found, however, that the rate of feed of the combustible liquid to the air reservoir increased very greatly as the pressure decreased and that consequently dangerously high temperatures were likely to be produced in the latter stages if the combustible liquid was fed at such a rate as to produce a rapid rise of temperature. It was in order to regulate the rate of feed that the invention shown herewith was devised.

According to this invention the progressive feeding of the combustible liquid into the air reservoir is dependent upon the fall of pressure in the latter. This is secured by extending the pipe connecting the fuel reservoir with the air reservoir, upwardly through the former, through the whole or a considerable portion of the vertical height thereof and in giving said pipe two or more openings of different heights permitting communication between the interior of the pipe and that of the vessel.



When the level of the combustible liquid has fallen sufficiently to expose one or more of these openings, the air confined in the air space of the fuel reservoir will begin to pass through the exposed opening, while the combustible liquid will continue to flow through those openings which remain submerged. The rate of feed will thus be diminished at the moment at which one of these openings is disclosed. The air space will increase to a less extent for a good reduction of pressure than it would have done had no air been allowed to escape from the fuel reservoir. Consequently the continuance of the discharge from the air vessel will not increase the rate of feed and the successive exposure of other openings in the fuel feed pipe will continue to check such rate.

The operation of the apparatus is as follows: As soon as the torpedo engine is started the pressure in the air reservoir naturally begins to fall and in consequence, the air in the space in the combustible reservoir expands, thereby driving the liquid through a spraying nozzle so that it enters the compressed air reservoir in a condition for rapid combustion. This spray is ignited by the firing of a primer and the fuel burns fiercely in the compressed air. Thus this expanded hot air is supplied to the engine through the pipe leading to the compressed air chamber. As the combustible liquid falls and exposes the holes in the exit pipe, air will pass through the exposed hole, but the combustible liquid continues to flow through those which are submerged. This passage of air reduces the stream of combustible liquid and also lessens the growth of the air space above it, thereby decreasing the rate at which the feed increases.

UNNECESSARY LOSS OF LIFE IN THE NEW YORK TUNNELS*

By R. W. Raymond.

In the *Journal* of June 2, 1906, I published an article on "Blasting in New York City," calling attention to the dangerous character of the method of rock-excavation commonly pursued by contractors in the tunneling now in progress under this city. My protest has received fresh emphasis from the recent loss of several lives, as a direct result of the system I condemned.

As I explained in the article referred to,† the usual present procedure is to drill deep converging holes in the face of the tunnel, explode in them heavy charges of dynamite, and thus produce an irregular cave, with shattered sides and roof. After removing the displaced rock, the desired section of the tunnel is perfected by further and less violent operations. This method is unquestionably objectionable from an engineering point of view, because it leaves the rock outside of the tunnel section more or less fissured. It is objectionable also by reason of the annoyance and injury which it inflicts upon overhead buildings and their occupants And to these grounds for its condemnation, we must add the further consideration that it is unnecessarily dangerous to workmen. The cave produced by violent large blasts must be entered, in order to remove the fallen and the loosened rock. During this operation there is great danger of the fall of part of the shattered roof. The work is consequently recognized as extra-hazardous, and men of special skill and courage are employed in it, and receive high wages on account of the risk they assume.

Thus, the other day, a workman who "knew no fear" and received on that account $7 per day, was killed by a fall of rock in one of the caves created by big blasts in a New York tunnel: and other lives, not thus paid for beforehand, were similarly sacrificed.

It cannot be too strongly declared that all this danger and destruction is unnecessary. It is perfectly practicable to run a rock tunnel by drilling a vertical centre cut, and blasting with light charges in holes parallel thereto, so as to avoid injury to persons or property, or even the annoyance of miniature earthquakes, now suffered by New York citizens whose lodgings are undermined by the progress of subterraneous public improvements.

I have recently heard from transient guests at the Waldorf-Astoria, and from permanent residents of that part of the city, vigorous complaints of the shocks received from tunnel blasts. Such parties are hereby notified that I cannot help them, except by publicly declaring, once more, that the nuisance of which they complain is wholly unnecessary. I do not even believe that the quieter and safer method of tunneling would be more expensive, if it were carried out with intelligence, and with loyalty on the part of subordinates and workmen.

But it is useless to argue that proposition, so long as specifications in contracts do not require the reform, and contractors are unwilling to introduce it, at the risk of a quarrel with labor. The only immediate remedy I can perceive is public opinion, such as is created by much talk, and especially by writing to the papers. Let my aggrieved friends say in these ways what they vainly say to *me* and something may come of it! For instance, juries may be led to grant heavier damages against contractors who persist in employing a method involving unnecessary risk of injury to person and property, and official boards may hereafter require of contractors the use of the safer method. Moreover, if the sufferers should make noise enough, even the present contractors may be scared into mending their ways. So, my advice to my correspondents is: Go on, and talk and write as often and as much as you can—only not to me!

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*Abstracted from Engineering and Mining Journal.

†See Compressed Air, August, 1906.

CHEAPER LIQUID AIR

Reduced cost of liquid air production is indicated by an article in the London *Times*. Recent experiments in England of an invention by Mr. Knudsen, a Dane, furnished liquid air at one-sixth of the present market price, and give promise of an ultimate low price of a fraction over two cents per gallon. The result is secured by purely mechanical means, without an atom of added chemicals. Atmospheric air is first purified and then compressed by stages to 2500 pounds to the square inch. It is finally reduced to 125 pounds to the square inch, which then cools and liquefies the high-pressure air.

The oxygen gas produced by separating the nitrogen from the liquid air is claimed to be purer than by the old method, and can be supplied in the liquid as well as the gaseous form. One gallon of liquid air equals approximately 128 cubic feet of oxygen gas, which retails at six cents a cubic foot. The new price is one cent. Liquid air has been successfully used in coal mines as an explosive, being quite safe where fire damp and other explosive gases exist. Liquid oxygen is also used for welding steel pipes, boiler shells, and plates for shipbuilding instead of riveting.

That oxygen and nitrogen can be separated from liquid air and sold retail at $1.20 a gallon shows great commercial possibilities. The use of nitrogen for agricultural purposes opens yet another field The maturing of liquors will be helped by liquid air, as also the preservation and purification of milk. As a motive power its use is considered to be quite practicable for small powers. The British government is already carrying out a number of experiments with a view to the utilization of liquid air for various purposes.

EXTRUDED METAL

One of the many interesting exhibits at the recent convention of the American Railway Master Mechanics and Master Car Builders, says *Cassier's Magazine*, was the product known as extruded metal, formed by the pressing of hot metal through a die, thus forming a great variety of intricate and fancy shapes adapted to many uses in car and locomotive construction.

The word "extrusion" accurately describes the operation by which the various sections are formed. A billet of brass is first cast of a convenient size and suitable composition for the purpose intended. This billet is re-heated until it is of a plastic consistency, and then, by means of a small crane, it is placed within a very strong horizontal cylinder or "container," at the front end of which is the die. Upon hydraulic pressure being applied at the rear end of the container, the plastic metal is forced or squirted through the die, issuing from it in a long bar having a cross-section corresponding to the section formed in the die.

The very high pressure (oftentimes as high as 60,000 lbs. per sq. in.) to which the semi-plastic metal is thus subjected gives it increased density and makes it perfectly homogeneous and free from possible casting defects. The bars produced by this process have a greater strength and tenacity than those made by rolling or other cold working methods, and for special purposes alloys are made having the requisite strength and elongation for work demanding the strength of good quality steel. It is also obvious that sections which cannot possibly be rolled or drawn can be made by the extrusion process with great accuracy

In addition to bars or rods of irregular cross-section, all stock sizes of round, hexagon, square, rectangular, half round, etc, are produced suitable for forging and all engineering purposes.

A considerable use that has been found for this metal is in the form of moldings for architectural work. It is well adapted for use in large stores and office buildings, railroad stations, residences, etc., and can be oxidized to give it any color desired.

THE "shell," or jacket guides, of a rock drill, when worn, allow the machine too much play, which is likely to break the feed screw and considerably affects the efficiency of the machine, inasmuch as it will waver slightly, each blow of the drill increasing the friction and thus reducing the efficiency.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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W. R. HULBERT, M. E., Assoc. Am. Soc M. E., . Managing Editor
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PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. JANUARY, 1907. No. 11.

THE WATER PUMPING PLANT AT JAMECO, L. I.

The daily newspapers have been devoting considerable space to a discussion of the water-pumping plant which Mr. Silas W. Titus has installed at Jameco, L. I., on account of the unique contract which he had made with the city concerning the water supply of Brooklyn. This contract involved the taking over of the management of the pumping plant, providing the city with its ordinary quota of 1,400,000 gallons of water per day, but for all the water delivered to the city above this quota he was to receive $40 per million gallons. This price was to run for four months after all the wells were in operation. After four months, and for the balance of time, twenty months, he was to receive $30 per million gallons and, if he stopped at the end of four months, the contract was to be terminated, but if he continued, it was agreed that he should put up a permanent pumping plant at his own expense, which was to become the property of the city at the end of the twenty months.

Mr. Titus now has his plant in operation and the results achieved thus far appear to be exceedingly satisfactory, both to Mr. Titus and to the city; although, to our minds, not so unusual as the newspaper reporters would lead one to believe. Mr. Titus has increased the output of the twenty-one wells comprising the plant from 1,400,000 gallons per day to 8,400,000 gallons, which, on the face of it, would appear to be a most exceptional increase. But, without desiring to disparage Mr. Titus' achievement, it must be remembered that this only amounts to an average of 278 gallons per minute from each well, while the air-lift system, which is the system of pumping that Mr. Titus has installed, has frequently shown a capacity considerably in excess of this amount. The total amount, however, is a very large yield for one particular district, and if Mr. Titus succeeds in increasing this yield, which he seems to have every prospect of doing, he will be entitled to a great deal of credit for his foresight and engineering ability.

The success of the air-lift system at Jameco brings out more strongly than ever the chief points of merit which have long been claimed for this method of pumping, namely, that the system is only limited by the capacity of a well to yield water, it having been demonstrated that it will not only pump all the water which a well will deliver, but will actually increase the capacity of a well with service, owing to the fact that it tends to clean out the well and to keep it clean, thus permitting of a more ready inflow of water.

We wish Mr. Titus all success with his undertaking and trust that he will achieve even better results in the future.

THE NEW PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

It will probably be most welcome news to members of the American Society of Mechanical Engineers and to engineers in general to know that Prof. Frederick Remsen Hutton has been rewarded for his long and very efficient service as secretary of the society by being elected to the presidency. As was pointed out in this paper some time ago, Prof.

Hutton resigned the secretaryship owing to the fact that he considered it necessary to devote more of his time to his duties as Professor of Mechanical Engineering at Columbia University.

Prof. Hutton was born in New York City, May 28th, 1853, and after a preparation in a private school, entered Columbia College, receiving the degree of A. B. in 1876. He then entered the School of Mines, taking its degree in the same year. The next year he was appointed an instructor in mechanical engineering, serving under the late Prof. W. P. Trowbridge. He entered the faculty as an adjunct professor in 1881 and became full professor in 1890, which position he has held ever since.

When Columbia moved from 49th street to its present site on Morningside Heights, Prof. Hutton was called upon to take charge of the erection and equipment of the mechanical engineering laboratories which now stand as a splendid monument to his achievement. It would be difficult to find mechanical laboratories more completely equipped than those at Columbia. This equipment includes a Reynolds triple expansion steam engine of 150 H. P., a Baldwin-Vauclain compound express locomotive of 1600 H. P. mounted on friction wheels, equipped with brakes and dynamometers in order that it may be tested for tractive effort and general efficiency. Other unique apparatus which Prof. Hutton has added to the laboratory includes an Otis hydraulic elevator, many high powered steam pumps, numerous gas and oil engines and other apparatus which has served to make the laboratory one of the finest in the country.

Columbia has honored Prof. Hutton with the degree of Ph. D. and later, at its 150th anniversary, with the degree of Sc. D., which is the highest that it confers in the field of science.

Prof. Hutton has served as secretary of the American Society of Mechanical Engineers since 1883 and now becomes its president at a time when the society, having grown steadily in membership and influence, is about to occupy its quarters in the magnificent new engineering building rapidly nearing completion on West 39th street, New York.

AIR BRAKES FOR MOTOR CARS

In one of our editorials last month on this subject we made the following statement: "It is not necessary to use an air compressor for operating air brakes, as the pressure can be obtained from the motor cylinders. This is an important point, as one of the chief arguments against air brakes for use on motor cars has been that the air compressor absorbed a great deal of power; in fact, it has been estimated that the power required to operate the air brakes of a motor car would be approximately one-tenth of the power of the engine which, in the case cited, amounted to three and a half H. P."

Our data for the above statement was obtained from an article by Mr. Thomas J. Fay in a recent issue of "The Horseless Age." Our attention has now been called to the fact that the above statement is in error, and we are in receipt of a letter from Mr. E. J. Stoddard, of Detroit, Mich., pointing out the fact that instead of the air brakes requiring 3½ H. P. they would only require 0.3 H. P. as calculated in the following manner: Average pressure on piston, 25 lbs.; area of piston, 3½ sq. in.; stroke, 3 in.; number of strokes per minute 450; then

$$\text{H. P.} = \frac{(3\frac{1}{2})\,(25)\,(450)\,(\frac{1}{4})}{33000} = \frac{9900}{33000} = 0.3$$

This puts the subject in an entirely new light and would tend to show that air brakes absorb but a slight amount of the power of the engine for their operation, and that they should, on that account, be received with more general favor by automobilists.

ATMOSPHERIC PRESSURE AS A STIMULUS TO CONVERSATION

Dr. Moorhead, of Washington, has recently reported to the Government with respect to some curious effects of rarefied and of condensed air on human respiration.

On high mountains some persons experience distressing "shortness of breath," on result of which they are unable to whistle. Precisely the same effect is sometimes produced by the condensed air in caissons and diving bells. Laborers working in compressed air frequently find, however, that their powers of exertion are increased as long as the atmospheric pressure is not more than double that of ordinary air; but beyond that point unpleasant effects are experienced after the men have left the working shafts and returned into the open air.

On the other hand, atmospheric pressure in the case of persons not doing manual labor has been found to act as a mental stimulus, increasing the impulse to talk.

Engineers in charge of the construction of the Pennsylvania tunnels assert that the safety appliances have reached such a state of perfection that the East River tunnels are now the best protected anywhere. The latest device is designed to keep workmen from being overcome by smoke in case of fire.

Formerly compressed air could come into an airlock only from the tunnel, and if the tunnel filled with smoke there was no way to get fresh air. Now a pipe connection is put in every lock so that fresh air can be let in by the mere turning of a valve. If smoke happens to collect in the tunnel the opening between it and the lock can be closed and the other pipe opened. In all four Pennsylvania Railroad tunnels under the East River at Thirty-fourth Street shields are now being pushed forward, both from Manhattan and Long Island City.

EVENING TECHNICAL COURSES AT COLUMBIA UNIVERSITY, NEW YORK

The board of extension teaching of Columbia University announces a series of nine evening technical courses which will be given at the university this winter, and lasting twenty weeks. The courses are under the immediate direction of Prof. Walter Rautenstrauch, of the Faculty of Applied Science, and are to be given by professors and instructors of the university and other persons especially qualified. Moderate fees ($7.50 to $15) are charged, and most of the courses are for two evenings a week. The courses are as follows:

Engineering Physics, as illustrated in the mechanical plants of modern buildings. (1) An elementary study of physics; (2) a practical study of steam and electrical machinery, heating, ventilating, water system, wiring, elevators, etc., included in the plant of Columbia University. For two classes of students: Those wishing an introductory study of physics as preparation to advanced study in electricity, steam, etc., another winter; those desiring practical training for positions as superintendents of buildings, engineers, janitors, etc.

Elementary Mathematics: Those parts of arithmetic, algebra, geometry and trigonometry used in technical work. Practice with engineering hand-books, tables, etc.

Drafting: A beginner's course; fits for positions as draftsmen: reading of drawings, etc.

Strength of Materials: A lecture course for those who design or manufacture machinery, or modern structures. With this course should be taken either the first or second of the two following courses in design.

Machine Design: Advanced drafting, computations, and designing for persons engaged in the design and manufacture of machinery.

Structural Design: Advanced drafting, computations, and designing for those who do structural work.

Electrical Engineering: A course especially for those engaged in electrical work of any sort.

Steam Engineering: A course for those engaged in the manufacture or management of steam machinery of any sort.

Special Engineering Problems: A study of any special elementary or advanced engineering problems desired by the student. Individual instruction will be arranged for such a period of time as the special problem may demand.

The courses will be given in the buildings of Teachers' College, Columbia University, at West 120th street and Broadway, which affords necessary lecture rooms, laboratories, drafting rooms, etc. A complete catalog of these courses will be sent on request by addressing Evening Technical Courses, Extension Teaching, Columbia University. Personal information may be secured Tuesday and Thursday evenings, between 7.30 and 9 o'clock, from Benjamin R. Andrews, Room 111, Teachers' College.

NEW PUBLICATIONS

Practical Lettering, by Thomas F. Meinhardt, being a series of plates with corresponding explanations for beginners, draftsmen, engineers, engravers, sign painters, stone cutters, lithographers, etc., with an original system for spacing, published by the Norman W. Henley Publishing Co., 132 Nassau Street, New York. Price 50c.

One of the most important characteristics of this work is the practical instruction which it gives on the subject of "spacing." This is of particular value, as upon the correct spacing of a title depends to a great extent its appearance, and nothing will mar the looks of a drawing more than incorrect or careless spacing of the lettering, and this is, of course, of even more importance in the work of engravers, sign painters and stone cutters.

While Mr. Meinhardt's book contains only twenty pages, 14x9 inches in size, it is exceedingly complete and the explanations, hints for pen-work, hints on duplicating and analysis of construction, are all that could be desired, the remarks on spacing, of course, going into the subject in great detail.

For all those having need of a work on lettering we should think this book would be a great help.

Penberthy Engineer and Fireman, published monthly by the Penberthy Injector Co., Detroit, Mich., 34 pages, 6x9, 25 cents per year.

This little magazine contains many original articles which should be of interest to steam engineers and firemen, relating, as they do, to principles of heat and practical management of steam engines and boilers. We should think the publication more than worth the subscription price to those interested in steam engineering.

TRADE PUBLICATIONS

Ernst Wiener Company, 68 Broad St., New York.—Catalog No. 80, 24 pages, 6x9, printed in both Spanish and English and devoted to the subject of locomotives for industrial railways. Full particulars are given concerning each locomotive illustrated, the information being arranged in tabular form.

Ingersoll=Rand Company, 11 Broadway, New York.—Bulletin No. 2008, on Imperial Motor Hoists and Stationary Motors. The pamphlet contains a complete description of the Imperial Motor Hoist with illustrations and tables of sizes and dimensions. The later pages of the publication are devoted to illustrated part lists on each machine for the assistance of purchasers in ordering duplicate parts. The pamphlet is 6x9 in size and consists of 32 pages.

Catalog No. X-36, 44 pages, 6x9, devoted to a description and full particulars of the Imperial Type 10 Air Compressors. The catalog is handsomely illustrated and all information concerning compressors, receivers, etc., is placed in tabular form for ready reference.

Charles H. Besly & Co., 15-21 South Clinton St., Chicago, Ill.—60-page catalog, 5½x9, devoted to Besly Spiral Disc Grinders, Band Grinders and Helmet Spiral Grinding Circles. The catalog is exceedingly complete, well illustrated and contains considerable information of a practical nature regarding method of holding work, etc., for machinists.

De la Vergne Machine Company, Foot East 138th St., New York.—4 page folder, describing the Klein Water Cooling Towers for cooling the jacket water of gas engines and for use in power plants, breweries, ice plants, etc. These towers will cool the water to from 5 to 15 degrees below the temperature of the atmosphere.

Blaisdell Machinery Company, Bradford, Pa.—46-page catalog, 6x9, illustrating and describing all types and sizes of Blaisdell Air Compressors. This catalog is known as Bulletin No. 18 and contains full information on air compressors of from 4 cubic feet per minute capacity up to 529 cubic feet capacity. It also covers the subject of pneumatic stone tools, plug drills, surfacing machines, unloading devices, gas and gasolene engines and equipment for complete pneumatic stone plants.

Independent Pneumatic Tool Company, First National Bank Bldg., Chicago, Ill.—4-page leaflet, describing Thaw Piston Air Drills, Pneumatic Hammers, Portable Grinding Machines, Riveters and Wood Boring Machines.

Abenaque Machine Works, Westmintes, Station, Vt.—24-page catalog devoted to gas and gasolene engines of from 2 to 25 H. P., the principal advantage claimed for them being the fact that gasolene is admitted to the cylinder and no carburetter is required. This is a very important advantage, as it enables the engine to be started in cold weather without trouble.

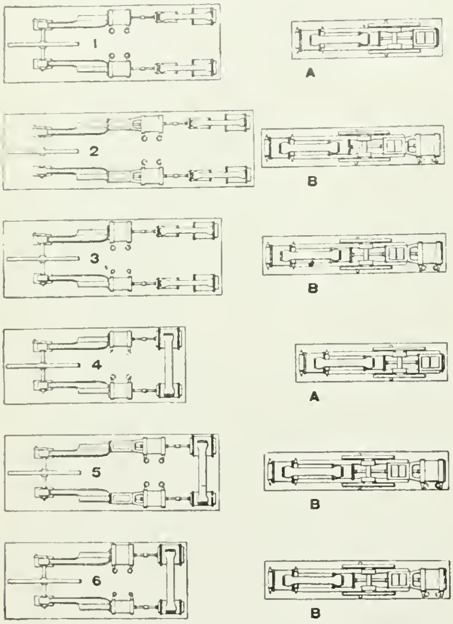
Sullivan Machinery Company, Railway Exchange Bldg., Chicago, Ill.—Mine and Quarry for November. This publication was reviewed in our columns when it first made its appearance and the November number, which is the third that has been issued, contains many articles which should be of interest to quarry men, mining superintendents and engineers in general. A particularly interesting article is one on drilling costs at a Newfoundland iron mine, which shows that proper methods of handling men and equipment may make the difference between loss and profit. Mine and Quarry is issued quarterly and will be sent to anyone on request.

INDUSTRIAL.

DUPLEX AIR COMPRESSORS

Under the impression that a duplex machine is easier to manipulate in starting or in slow running, some customers call for the duplex pattern. The supposed advantages do not exist when comparison is made with an up-to-date straight-line machine, and there are certain disadvantages which it is well for the buyer to know before completing a contract.

For any given output of air they are more expensive in first cost and up-keep, for there is double the machinery. There are double the chances of delays, for either side may be necessarily stopped and then all air is shut off until adjustments can be made to both machines, and a heated journal on either side stops both.



Diagrams Showing Floor Plans of Compressors.

The generally observed friction of the duplex machines exceeds by about 5 per cent. the friction of two machines working separately.

For compound air compression duplex compressors are furnished in six varieties:

1st. Twin tandem compound air cylinders and twin simple steam cylinders.

2d. Twin tandem compound air cylinders and twin compound steam cylinders.

3d. Twin tandem compound air cylinders and cross-compound steam cylinders.

4th. Cross-compound air cylinders and twin simple steam cylinders.

5th. Cross-compound air cylinders and twin compound steam cylinders.

6th. Cross-compound air cylinders and cross-compound steam cylinders.

Of these patterns only the first two allow either side to be disconnected and the other side then runs as a complete machine.

The last four on the list are open to the objection that under no circumstances can one side be operated as a complete machine, for the cross-compound feature requires the operation of both sides at the same time.

The accompanying skeleton diagrams show floor plans of compressors of several kinds, all of the same capacity, and opposite each duplex machine is shown a straight-line machine for doing the same work at the same number of revolutions per minute.

Pattern A is a straight-line compressor with compound air end and simple steam end.

Pattern B is a compound air end and compound steam end.

These two patterns of straight-line compressors perform their work with the same steam economy as the corresponding duplex machine and do it with fully 5 per cent less internal friction.

The smallest duplex compressor occupies twice the floor space of the largest straight-line double compound compressor.

Foundations, engine rooms and piping adds expense in proportion to the floor space of the compressors.

As to the mechanism—by many it is thought that the term "complex" is a much more appropriate name than "duplex."

In the line of power-driven machines something can be said in favor of the duplex. In some exceptional cases of steam-driven machines there may be a debatable choice, but in the vast majority of installations the duplex has no advantages. The Norwalk Iron Works, of South Norwalk, Conn., can supply the compressors in single and compound steam patterns and in compound, three and four-stage air ends.

TRACING CLOTH NOW MADE IN AMERICA

Readers of Compressed Air will be interested in the fact that tracing cloth is now being manufactured in the United States. The domestic product is claimed to be equal in every respect to the imported cloth, having all the qualities a perfect tracing cloth should have.

The domestic tracing cloth is made by the American Tracing Cloth Company, having its offices at 11 Broadway, New York City, while the plant is located at Paterson, N. J. The cloth is sold under the name of Peerless. The company is believed to have accomplished quite a feat in succeeding in the manufacture of tracing cloth in this country, as many have tried to do so, but have not succeeded in producing a marketable article on account of unfavorable climatic conditions characteristic of this country which they could not overcome.

The American Tracing Cloth Company has, however, succeeded in creating the conditions necessary for the manufacture of tracing cloth by special means which they guard carefully. It was also necessary specially to design the machinery with which tracing cloth may be made here, and the company holds several strong patents on these designs. The credit of discovering the process is due to a graduate of a German university, who is very prominent in his profession, while the machinery was designed by an experienced man who has had a long and successful career in textile work.

Strong financial interests are stated to be backing the company, and the managers are quite confident that their product will in time replace the imported article, when the consumer has found out that he can purchase a perfect tracing cloth made in this country and at a cheaper price.

THE Union Switch & Signal Co. has been awarded the entire contract for the interlocking and signaling of the great terminal station being constructed in Washington, D. C., by the Pennsylvania and the Baltimore & Ohio railroads. The installation will be electro-pneumatic, similar in its general characteristics to that in the railway yards of the Pennsylvania at the Union station in Pittsburg. The Washington installation, however, will be the largest and most complicated signaling and interlocking installation that has ever been constructed in the world. The largest one previous to this was put in service at St. Louis at the beginning of the World's Fair, and before that the most important was the electro-pneumatic interlocking system at the terminals of the Boston South station. Both of these plants were also installed by the Union Switch & Signal Company.

SELF-STARTING DEVICE

Of all the self-starting devices offered for use on motor cars one of the best was exhibited at the Automobile Show, Grand Central Palace, Manhattan, December 1 to 8. It comes from Chicago and consists of a reservoir of compressed air maintained constantly by the operation of the engine. When the engine has stopped the pressure remains constant until starting. Two of the cylinders are filled with compressed air, which turns the engine over, drawing the gasoline into the two remaining cylinders, where it is ignited in the usual manner.

It is stated that the general use of compressed air in boiler shops, which has largely aided in advancing boiler shop practice to the front rank in railway mechanical departments, is being extended in some shops to include the cleaning of crown bars and crown sheets with a sand blast. It is claimed that this gives much more satisfactory results than the old method of hammer and chisel. In a certain shop where the new method has been installed a dozen bars took a man ten hours under the discarded system, at a labor cost of $1.75. With the sand blast a bar is cleaned in 20 or 30 minutes, or about half the former time, and the job is a cleaner one when done. This same shop uses the blast with satisfactory results for cleaning the crown sheet as well.

LUBRICATION IN COLD WEATHER

An interesting argument in favor of graphite as a lubricant is put forward by the Dixon Crucible Company of Jersey City, N. J. It is claimed that almost any bearing that requires oil in it will work harder in winter than in summer, as the oil is bound to be more viscous when cold than when warm. It is for this reason that experienced men who have tried it suggest that a possible solution of difficulties in lubrication may be found in the use of flake graphite along with some thin mineral oil. The lubrication will be as good, if not better, and the drag and slowness will disappear.

THE Crandall Packing Company, Chicago, Ill., announce that owing to increased business their Cleveland office has been moved from 9 South Water Street to 805 Superior Street, N. W., in the Wade Building, where their stock has been greatly enlarged in order to enable them to take proper care of their stationary and marine business which is being handled from the Cleveland office. They also announce that their latest catalog is just off the press and will be forwarded to engineers upon request

FOR transmission of power in mines where compressed air is used, it has been found that, for general purposes, a moderate pressure of $6\frac{1}{2}$ to 7 atmospheres is the best practice.

In drilling with machines it does not pay to overload an air-compressor with too many drills, or to use a main pipe so small as to reduce the air pressure materially. Experiments show that a drop of pressure from 75 to 45 pounds will reduce the length of hole drilled by more than 50 per cent. Great care should be taken to have no leaks in the pipe line, especially in the hose and couplings.

In the operation of air compressors the best results are obtained, it is said, when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5,500 feet per minute. On a compressor run with a piston speed of 550 feet per minute, this requires a valve area equal to 10 per cent. of the piston area. The practice of making suction valve areas larger than those of the discharge valves is not advised as, while the incoming air is of greater volume, the discharge valves remain open for a very small proportion of the stroke.

Compressed air differs from electricity, especially in the fact that electrical friction losses cannot be regained, while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments a loss of transmission. "If the air were at 80 lb. gage or 95 lb. absolute upon entering the pipe, and 70 lb. gage or 85 lb. absolute at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent."

VALUE OF TECHNICAL PAPERS

The advancing foreman of to-day must be up to new ideas and keep moving; he has no time to sit with his hands folded. The proper use of mechanical literature is the foundation of success. The good, energetic mechanic waits hourly for his mechanical journal to arrive; how would our minds be enlightened if it were not for this? We would never have anything before us that would give us any reason to improve or make improvement. Every month there is something new that is very beneficial to the mechanic, and, I am sorry to say, there is not one-half of the mechanics reading these papers that should be. The country has produced some of the finest graduates in the mechanical line, and it is these who are worrying their minds about modern mechanics and improvements that when published are beneficial to you and me. I think if every foreman would stop long enough to think where he is in this hustling, modern, improved mechanical world, he would subscribe for more mechanical literature.—*G. W. Keller, before the Convention of the International Railway General Foremen's Association.*

PUMPING WATER BY COMPRESSED AIR

The greater portion of the sugar factories in Louisiana, are to a great extent, dependent upon their water supply for condensation purposes, from deep wells.

These wells are usually of 4 to 10-inch piping sunk to a depth varying from 180 to 1,000 feet, according to location and water strata.

The usual practice is to use steam pumps and they do fairly well when large pumps, or enough of them are used, to help the pumps as much as possible. The water, after leaving the condensers, is circulated through a long ditch back to the supply pond in order to cool the water until repeated use compels us to turn it out to flow away.

A certain factory here has an 8-inch well 233 feet deep, but when these wells are sunk and water is struck, the water rises from within 10 to 20 feet of the surface. A large duplex pump was connected to the well and by working the pump to its utmost capacity, 250,000 gallons every 24 hours was the best it could do. As the factory wanted 500,000 gallons every 24 hours, the water had to be used several times and would be so hot that the required vacuum could not be maintained.

An air compressor of the flywheel type was next tried with results that settled the question then and there, as to the superiority of the air system over the steam pump. A receiver was placed between the pump and the well and a $1\frac{1}{2}$-inch pipe was run to the well and down to a depth of 165 feet. At the bottom was placed a very simple arrangement to discharge the air upward.

It required a little over 65 pounds air pressure to start the water flowing and then the pressure would drop to 60 pounds. One million gallons every 24 hours was discharged from the well. As only one-half of that amount was needed the compressors were run quite slowly.—*F. B. Dunning in the Engineers' Review.*

CHOOSING AN AIR COMPRESSOR

The following is some advice given by the *Record and Guide* to its readers on the selecting of an air compressor:

"Direct steam-driven compressors are generally more desirable, being entirely independent of engine or motor, shafting or belts, but special conditions frequently demonstrate the advisability of using a compressor driven by belt, gear or chain from electric motor, gas engine or other power, rather than by steam direct.

"When obtaining proposals upon steam-driven compressors, the steam pressure available at the throttle should be stated. If a power-driven compressor is contemplated, the horse-power available for operation should be considered in conjunction with the volume of air and pressure required to perform the desired service.

"When selecting an air compressor it is unwise to consider immediate needs only, for the introduction of a compressor is invariably followed by demands upon it not originally contemplated. Good practice suggests installing a compressor possessing a sufficient margin of reserve capacity to meet the additional needs that are sure to follow.

"After the required volume and pressure of air have been determined, the next consideration is to fix upon the size, type and make of compressor to be selected, and therein lies one of the most important features of the problem. A too frequent error is to regard low first cost as the primary consideration. The air compressor that is cheap in first cost sometimes proves more expensive in the end, through greater power consumption and frequency of repairs.

The list of air compressor manufacturers rate the free air capacity theoretically; in other words, the area of the cylinder is multiplied by the rate of piston speed, without allowance for the unavoidable losses in air compression due to heat, friction and clearance. The percentage of loss chargeable to these causes is naturally, directly dependent upon the efficiency of the air compressor, suggesting the inevitable conclusion, that the difference in first cost when invested in the most economical compressor earns a handsome interest, through the saving effected in reduced power consumption and general operating expenses.

"The comparative economy of air compressors is not as frequently investigated and determined as it should be. In a water pump or steam engine, decreased efficiency becomes readily discernible, but the deficiencies of an air compressor are not as promptly brought to view. Compressed air, if one would realize all the commercial economies and benefits that accrue, should be produced with the best machinery obtainable and utilized with the most improved equipment and appliances. For similiar reasons a second-hand air compressor, unless first repaired by a reliable maker, is rarely a wise purchase. Under any circumstances the suitability of a second-hand air compressor for the service intended should be carefully considered, especially as to its proper proportion for the air pressure required and (if steam driven) the steam pressure available."

HIGH pressure gas distribution by the Western United Gas & Electric Co. supplies 24 cities and towns west of Chicago, the population served being about 140,000, and the line fifty-two miles in length. The most interesting feature of the system is the concentration of all the gas manufacturing at Joliet, making all the other consumers in the district dependent upon the pressure lines. With an initial pressure of 50 lbs. per square inch at Joliet, the drop in the 8-in. main to Copenhagen, 16½ miles, is 10 lbs. From this point a 6-in. main runs to Aurora, 7½ miles, with a further drop of 10 lbs. From this point a line to Elgin consists of 5 and 4 in. pipes, the distance being 23 miles, and the resultant pressure barely enough for the distribution. It is proposed to introduce pumping machinery at Elgin, in order that the system may be still further extended, without the necessity for raising the initial pressure above 50 lbs.

U. S. PATENTS

ESPECIALLY PREPARED FOR COMPRESSED AIR

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents. Washington, D. C. (Stamps will not be accepted.)

832,791. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal. Filed July 12, 1905. Serial No. 269,407.

Claim.—In a rock-drilling machine or engine, a rotatable power-cylinder having a side port at its forward end, a drill-steel slidably and non-rotatably held at said forward end of the power-cylinder, and having a passage extending longitudinally of said steel and communicating with the side port aforesaid, and a liquid-supply swivel loosely surrounding the forward end of the power-cylinder and having a port in communication with the side port aforesaid.

832,812. AIR-COMPRESSING APPARATUS. William A. Rohr, Sorel, Quebec, Canada. Filed Dec. 11, 1903. Serial No. 184,821.

Claim.—In an air-compressing apparatus, the combination with a base, a weighted rotary member adapted to rest upon such base, and means for rolling the said member to and fro, of a cylinder, means pivotally supporting such cylinder below the surface of the said base, means for supporting the cylinder in an angular position facing the end of the base from which the member rolls, a piston movable in the cylinder, a piston-rod connected at one end to the piston, means yielding supporting the said piston with the opposite end of the piston-rod normally above the level of such surface and in position to be acted upon and depressed by the weighted member, the said cylinder being adapted to oscillate in a plane parallel to the direction of travel of the rotary member and move with the said member while the latter acts upon the piston-rod.

833,002. SYSTEM OF REGULATING FLUID-PRESSURES. Frederick Robbin, New York, N. Y. Filed June 21, 1905. Serial No. 266,265.

833,062. RELIEF-VALVE. William F. Krichbaum, Newark, N. J., assignor, by direct and mesne assignments, to Foster Engineering Co., Newark, N. J., a Corporation of New Jersey. Filed Sept. 23, 1905. Serial No. 279,795.

833,079. PRESSURE-REGULATOR. William O. McCullough, Chicago, Ill. Filed Jan. 2, 1906. Serial No. 294,247.

833,087. SELF-REPLENISHING FLUID POWER-TRANSMITTER. Percy F. Rice, Tustin, Cal. Filed Jan. 16, 1906. Serial No. 296,244.

833,093. AIR-VALVE FOR RADIATORS. Henry M. Stevenson, Perry, Iowa. Filed Aug. 2, 1905. Serial No. 272,426.

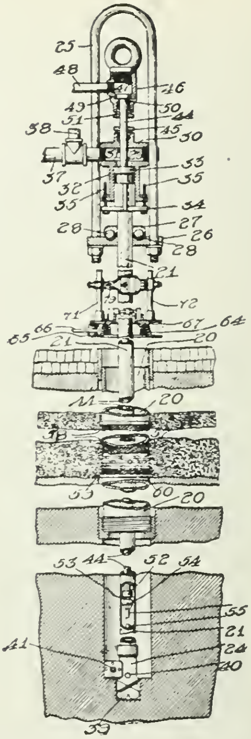
833,149. LUBRICATOR. George H. Annan, Providence, R. I., assignor to Jolt Lublicator Company, Providence, R. I., a Corporation of Rhode Island. Filed Nov. 1, 1905. Serial No. 285,411.

833,161. FLUID-PRESSURE BRAKE. Richard Fitzgerald, Chicago, Ill. Filed July 7, 1903. Serial No. 164,530.

833,200. WELL-SINKING APPARATUS. Matthew T. Chapman, Aurora, Ill. Filed July 15, 1901. Serial No. 68,383.

833,201. WELL-SINKING APPARATUS. Matthew J. Chapman, Aurora, Ill. Original application filed Sept. 25, 1899. Serial No. 731,507. Divided and this application filed Dec. 15, 1903. Serial No. 185,324.

Claim.—In a well-sinking apparatus, the combination of a swiveled head having an air-pipe connected therewith and extending down into the well, a swiveled well-tube through which said air-pipe extends, said air-pipe opening into the well-tube below the level of the water, whereby the water and debris may be discharged from the well, means for rotating said well-tube, and a drill at the lower end of the well-tube, said drill being hollow and having openings for the admission of water to said well-tube, substantially as described.



833,206. AUTOMATIC RAILROAD-SIGNAL. John P. Egan, Milford, Mass. Filed July 18, 1906. Serial No. 326,739.

833,215. PEDAL ATTACHMENT FOR PNEUMATIC INSTRUMENTS. Charles H. Hubbell, Derby, Conn., assignor to The Sterling Co., Derby, Conn., a Corporation. Filed Feb. 12, 1906. Serial No. 300,646.

833,234. PNEUMATIC-TIRE SHIELD. Joseph H. Lowrey, Neola, Iowa. Filed Sept. 26, 1905. Serial No. 280,111.

833,299. OIL-BURNER. Albert C. Butler, Crandall, Tex. Filed Oct. 6, 1905. Serial No. 281,667.

833,305. ELASTIC-FLUID TURBINE. Charles W. Dake, Grand Rapids, Mich. Filed Nov. 29, 1905. Serial No. 289,654.

833,306. ELASTIC-FLUID TURBINE. Charles W. Dake, Grand Rapids, Mich. Filed Nov. 29, 1905. Serial No. 289,657.

833,325. REFRIGERATING-MACHINE. William C. Hiester, Dayton, Ohio. Filed July 22, 1905. Serial No. 270,874.

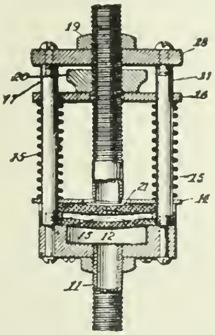
833,441. RIVETER. Samuel S. Caskey, Philadelphia, Pa., and Samuel C. Bond, Wilmington, Del.; said Bond assignor to said Caskey. Filed April 4, 1902. Renewed March 16, 1906. Serial No. 306,347.

Claim—In a riveting device, a hollow rivet-set and plate-clamping device, a rivet-driving bar, means for operating said set to bring the same in proper position whereby said set clamps the plates, means for operating the bar independently of said set to form the rivet, and means within the clamping device for engaging the inner end of the rivet-set to limit the movement of said bar within the set and prevent its passage therethrough whereby the head is formed within the set.

833,568. CHANGE-MAKING MACHINE. Joseph N. Warner, St. Paul, Minn. Filed Nov. 18, 1905. Serial No. 288,002.

Claim.—The combination with a fluid-pressure-distributing valve, of a bill adapted to be perforated to indicate the money received and the items of purchases, and change making and delivering mechanisms controlled by the flow of pressure through the perforations in said bill to discharge the desired change.

833,368. PRESSURE-REGULATED AIR-VALVE. **Zeno C. Brewster**, Oxford, N. Y. Filed June 20, 1905. Serial No. 266,184.



Claim.—In an air-compressor, the combination of an air-intake pipe having one end open toward the atmosphere, a valve adapted to move toward and from the open end of the intake-pipe and having one side subject to the pressure of the atmosphere, springs acting on the valve in conjunction with the atmospheric pressure, and a connection whereby the other side of the valve is subject to the pressure of the compressed air.

833,570. AUTOMATIC PRESSURE-RETAINING VALVE. **Alonzo Ashcraft**, Fort Smith, Ark. Filed Nov. 29, 1905. Serial No. 289,616.

833,702. AUTOMATIC FLUID-COUPLING. **Charles H. Tomlinson**, Denver, Colo., assignor to The Tomlinson Coupler Company, Denver, Colo. Filed Sept. 22, 1905. Serial No. 279,623.

833,710. PNEUMATIC TOOL. **Nathan W. Fletcher**, Chicago Heights, Ill., assignor to Turbine Motor Tool Company, Chicago, Ill., a Corporation of Illinois. Filed May 20, 1904. Serial No. 208,981.

Claim.—The combination of a supporting-plate provided between its ends with a curved portion having opposite, parallel, concave and convex surfaces, a base-plate attached to the upper surface of said supporting-plate, a motor mounted on said base-plate, a tool-spindle mounted in said supporting-plate, driving means connecting the rotative member of the motor with said tool-spindle, a saddle-block having a concave surface adapted to fit the convex surface of said supporting-plate, and a clamping-bolt inserted through the curved portion of the supporting-plate and through said saddle-block.

833,938. CHANNELING-MACHINE. **William Prellwitz**, Easton, Pa., assignor to The Ingersoll-Sargeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed April 1, 1905. Serial No. 253,248.

833,939. STRAIGHTWAY VALVE. **William T. Rider**, Coxsackie, N. Y. Filed March 10, 1905. Serial No. 249,424.

833,981. DETACHABLE PNEUMATIC TIRE. **Charles S. Scott**, Cadiz, Ohio. Filed Oct. 30, 1905. Serial No. 285,059.

833,992. AIR-BRAKE FOR AUTOMOBILES. **Alexander Winton** and **Harold B. Anderson**, Cleveland, Ohio, assignors to The Winton Motor Carriage Company, a Corporation of Ohio. Filed Aug. 10, 1905. Serial No. 273,631.

834,012. AUTOMATIC GLASS-BLOWING APPARATUS. **Fred S. Lewis**, Port Allegheny, Pa., assignor of one-fourth to William J. Edgar, Port Allegheny, Pa. Filed Feb. 17, 1906. Serial No. 301,666.

834,067. SAND-BLAST APPARATUS. **Charles A. Loughman** and **Karl Hess**, Braddock, Pa. Filed Nov. 13, 1905. Serial No. 287,141.

834,116. SANDING DEVICE. **James W. Foixey**, Newport News, Va. Filed April 21, 1906. Serial No. 313,060.

834,185. AIR-PRESSURE-SUPPLY APPARATUS FOR ATOMIZERS. **Charles E. Campbell**, Ashland, Ohio, assignor to The Faultless Rubber Company, Akron, Ohio, a Corporation of Ohio. Filed Feb. 13, 1906. Serial No. 300,890.

834,343. AIR-BRAKE APPARATUS. **Walter V. Turner**, Wilkinsburg, and **Edward A. Wright**, Edgewood Park, Pa., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Feb. 17, 1905. Serial No. 246,025.

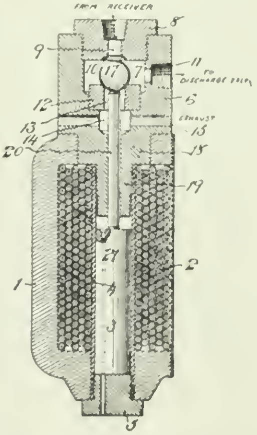
834,344. FLUID-PRESSURE BRAKE. **Walter V. Turner**, Wilkinsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Aug. 22, 1903. Renewed March 15, 1906. Serial No. 306,260.

834,441. ROCK-DRILL. **Thomas E. Adams**, Cleveland, Ohio. Filed July 29, 1905. Serial No. 271,806.

Claim.—In a drill, the combination with a barrel, of a drive-piston in the barrel, a driven piston in the barrel, and manually-controlled means for maintaining air at proper density between said pistons and similar means for maintaining the air at proper density on the opposite sides of the pistons to compel the driven piston to move with the driver.

834,522. ROCK-DRILLING MACHINE OR ENGINE. **Henry Hellman** and **Lewis C. Bayles**, Johannesburg, Transvaal. Filed Jan. 11, 1905. Serial No. 240,661.

834,626. UNLOADER FOR SINGLE-ACTING COMPRESSORS. **Frederick Van Duzer Longacre**, New York, N. Y., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Nov. 23, 1904. Serial No. 234,011.



Claim.—An air-compressor, a discharge-valve therefor and an unloader comprising a valve-box, its chamber having a pressure-supply port, a discharge-valve port in communication with the back of the discharge-valve, and an exhaust-port, a valve arranged to alternately open and close communication from the pressure-supply port and the exhaust-port to the discharge-valve port and electrically-controlled means for operating the valve.

834,641. PNEUMATIC HAMMER. **Conrad Pruner**, Wiener-Neustadt, Austria-Hungary. Filed Dec. 29, 1903. Serial No. 187,050.

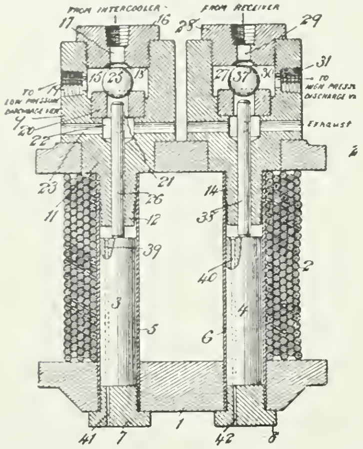
834,837. AIR-BRAKE BLEEDING-VALVE. **Herbert A. Miner**, Logansport, Ind., assignor of one-half to Charles P. McCaffrey, Logansport, Ind. Filed June 12, 1906. Serial No. 321,417.

832,653. ELECTRICALLY-DRIVEN MOTOR. **Gaston A. Bronder**, Brooklyn, N. Y. Filed Feb. 12, 1903. Serial No. 143,134.

834,937. AIR-STRAINER. **Frank Robinson**, Bangor, Me., assignor to The Robinson Company, Bangor, Me., a Corporation of Maine. Filed March 12, 1906. Serial No. 305,520.

834,997. DUST-REMOVER AND AIR-PURIFIER. **Richard J. Radike**, St. Clair, Mich. Filed April 21, 1906. Serial No. 313,087.

834,627. UNLOADER FOR COMPOUND COMPRESSORS. Frederick Van Duzer Longacre, New York, N. Y., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Nov. 23, 1904. Serial No. 234,012.



Claim.—A compound air-compressor, discharge-valves therefor and an unloader provided with a plurality of valve-chambers, each valve-chamber having a pressure-supply port, an exhaust-port and a discharge valve port in communication with the back of one of the discharge-valves, a valve for alternately opening and closing communication from the pressure-supply port and exhaust-port to the discharge-valve port and electrically-controlled means for operating the valves.

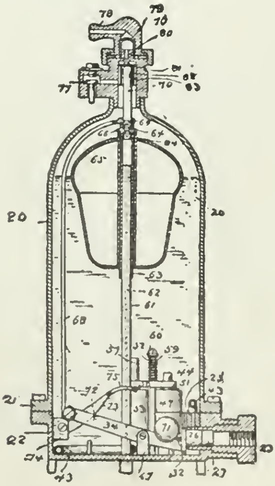
835,005. WHEEL-TIRE. Arthur S. Allen, Brookline, Mass. Filed March 6, 1905. Serial No. 248,466.

835,184. GATE. William P. Elliott and William P. Elliott, Jr., Chicago, Ill. Filed Aug. 27, 1906. Serial No. 332,218.

835,247. SHOCK-ABSORBER. Charles Morgan, South Orange, N. J. Filed Jan. 11, 1906. Serial No. 295,605.

835,261. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Filed Aug. 12, 1905. Serial No. 273,930.

835,291. AUTOMATIC AIR-COMPRESSOR. John Rogers, Bridgeport, Conn. Filed Nov. 6, 1905. Serial No. 286,037.



Claim.—An air-compressor comprising a cylinder having induction and eduction connections and induction and eduction valves, a pipe leading from the induction-valve, means whereby fluid in said pipe will actuate the eduction-valve, a float and intermediate connections whereby when the cylinder is filled the induction-valve is closed and water permitted to pass through said pipe to open the eduction-valve, and when the cylinder is emptied the induction-valve is opened and the eduction-valve drained through said pipe and induction-valve and permitted to close.

835,391. WATER-ELEVATING APPARATUS. Frank Allison, Chattanooga, Tenn. Filed Nov. 25, 1905. Serial No. 289,093.

Claim.—A water-elevating apparatus comprising a pair of tanks having check-valved supply and discharge connections at their lower ends, a source of compressed-air supply, a chest communicating therewith and with the upper portions of the tanks, a piston-valve operated in said chest to alternately control the supply and exhaust of air to and from the tanks, air-feed pipes communicating with the source of air-supply and leading into the upper portions of the tanks, vent-pipes, combined air feed and exhaust pipes leading from the source of air-supply to the respective ends of the chest, valves connecting said pipes and each having an oscillatory valve member adapted in one position to connect the air-feed pipes with the combined air feed and exhaust pipes and in another position to connect the latter-named pipes with the vent-pipes, levers centrally pivoted to the stems of said valve members, a weight connected to one end of each lever, a bucket disposed in each tank, and a connection between said buckets and the other end of the lever.

835,442. AIR-RELIEF FOR LIQUID-RECEPTACLES. Lewis Landau, San Francisco, Cal., assignor to Landau Economic Siphon Company, San Francisco, Cal., a Corporation of California. Original application filed Dec. 7, 1905. Serial No. 290,739. Divided and this application filed May 31, 1906. Serial No. 319,641.

835,467. ENGINEER'S VALVE. William K. Rankin, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 3, 1906. Serial No. 294,379.

835,468. ENGINEER'S VALVE. William K. Rankin, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 30, 1906. Serial No. 298,693.

935,589. PNEUMATIC TOOL. Wells Wheeler, East Pittsburg, Pa., assignor of one-half to Frank W. Chattin, Butte, Pa. Filed Dec. 23, 1905. Renewed Oct. 3, 1906. Serial No. 337,277.

Claim.—In a percussion implement, the combination of a tool-actuating cylinder, a piston therein, a compressing-cylinder and piston therein, connections between said cylinders, a by-pass connecting the ends of the compressing-cylinder, and valve mechanism arranged to keep said by-pass open during a predetermined number of reciprocations of the compressing-piston and close the same during the next reciprocation of said piston.

835,775. PRIMARY PNEUMATIC VALVE. George P. Brand, New York, N. Y. Filed Jan. 31, 1905. Serial No. 243,464.

835,774. AIR TENSION-MOTOR. George P. Brand, New York, N. Y. Filed Jan. 15, 1904. Serial No. 189,101.

835,776. TRACKER-BAR FOR PNEUMATIC PLAYERS FOR MUSICAL INSTRUMENTS. George P. Brand, New York, N. Y. Filed Feb. 23, 1905. Serial No. 246,865.

835,777. MEANS FOR AUTOMATICALLY CONTROLLING PNEUMATICALLY ACTUATED DEVICES. George P. Brand, New York, N. Y. Filed Jan. 16, 1906. Serial No. 296,313.

835,778. PNEUMATIC VALVE-SEAT. George P. Brand, New York, N. Y. Original application filed Jan. 13, 1905. Serial No. 243,463. Divided and this application filed Feb. 10, 1906. Serial No. 300,432.

835,782. PNEUMATIC FAN. John H. Creveling, New York, N. Y., assignor to Safety Car Heating & Lighting Company, a Corporation of New Jersey. Filed Nov. 18, 1901. Serial No. 82,716.

835,808. TIRE. Henry T. Bragg, Yonkers, N. Y. Filed Jan. 16, 1906. Serial No. 296,260.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

FEBRUARY, 1907.

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THE NEW BLISS-LEAVITT TORPEDO FOR THE UNITED STATES GOVERNMENT

IT IS OPERATED BY RE-HEATED COMPRESSED AIR.

The new Bliss-Leavitt torpedo embodies the latest improvements in torpedo design and construction and also embraces many features peculiarly its own. The new weapon has been described in great detail in the Journal of United States Artillery and we are indebted also to the manufacturers, the E. W. Bliss Co., of Brooklyn, N. Y., for the illustrations which we are enabled to produce, showing the new torpedo ready for service, and also during various stages of its manufacture.

The new torpedo conforms, in its external appearance and in the leading features of its internal subdivision and method of control, to the Whitehead, but in size, power, speed, range and accuracy it far surpasses it. The 18-in. torpedoes have a length of 16 ft. 6 in. The charged weight, ready for ejection, is 1,300 lbs. They have an effective range of 2,000 yards, as against 1,500 yards for the Whitehead torpedo. Their speed is 36 knots, as against 28 knots. The 21-in. torpedoes, the largest size, have a guaranteed range of 3,600 yards, and will probably reach 4,000 yards.

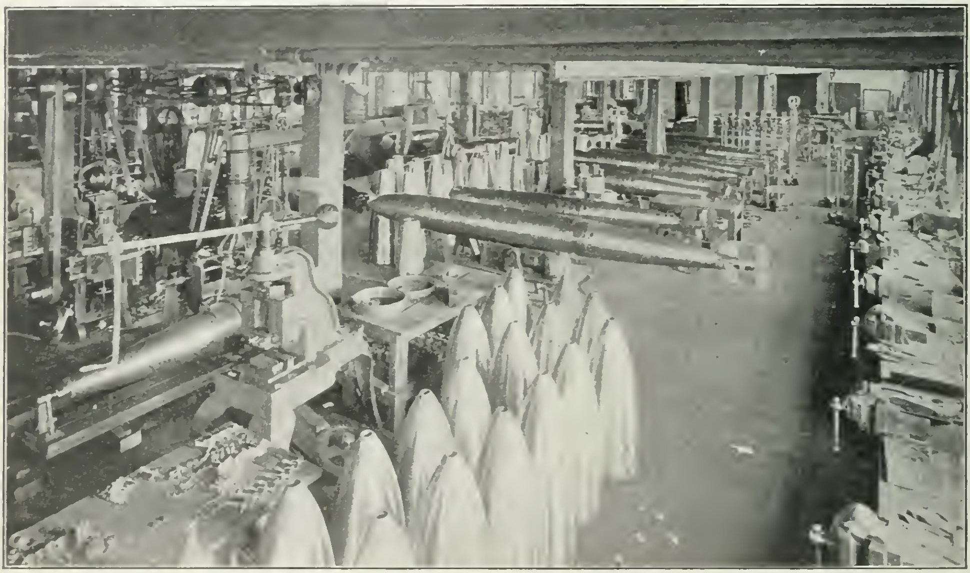
The shell of these torpedoes is composed essentially of three parts, namely, a central flask, a head and an after body which contains the turbine for operating the propellors, the immersion chamber for regulating the depth of the torpedo beneath the surface of the water and the gyroscope gear by which the torpedo is automatically steered and maintained on its proper line of flight. The float, which is a little over one-half of the total length, is made of a special steel having an elastic limit of 90,000 lbs. and a tensile strength of 128,000 lbs. It is delivered to the works as a cylinder having a thickness of over 1 in. and is turned down to a thickness of 3-8 in. This is done as a precaution in order to reveal any defects in the metal. The great strength is required by the use to which the flask is to be put. It serves as a reservoir for the air operating the engine, and is charged at a pressure of 2,250 lbs. to the square inch. The ends of the flask are closed by a dished plate resembling the manhole plate of a boiler. This plate rests against a ring secured within the flask

The after portion of the torpedo, or the tail, contains in its forward end the engine which drives the propeller. The torpedo is operated by a turbine engine of the Curtis compound type, having two wheels 11 ins. in diameter and each having 84 buckets. The wheels make 1,200 r. p. m. The engine develops 110 h. p. as against 35 to 40 in the 3 cylinder engines heretofore employed.

It should be mentioned here that the remarkably high efficiency in speed and range of the new torpedo is due to the use of a superheating process applied to the compressed air. This consists of a flame which is automatically ignited, the instant the torpedo is launched from the tube, and which burns during the entire run. The compressed-air flask contains a burner or pot the flame of which is fed automatically with alcohol. The flow is so regulated that an even and steady temperature is maintained in the air flask.

The propellor shaft is driven directly from the engine. The rear propeller is rigidly mounted on the shaft, while the forward one is carried by a sleeve. The latter propellor is moved in the opposite direction by means of the usual system of three-bevelled gears. This ensures an even keel. With the introduction of the cigar-shaped torpedo came the double driving propellers—two sets of blades carried on the same shaft, but turning in opposite directions. Rigid vertical fins were tried for the purpose of keeping the torpedo on an even keel, but not with much satisfaction.

Immediately astern of the compartment containing the turbine is the apparatus for maintaining the proper depth of immersion and for steering. The regulation of the depth is effected by means of a vertical diaphragm, on one side of which is the water, which is allowed to enter by holes provided in the shell for that purpose, and on the other side a series of coiled springs, the water pressing against the diaphragm on one side, and the springs pressing the diaphragm in the opposite direction on the other side. The springs are adjusted so that their pressure shall exactly equal the pressure of the water at the given depth at which the torpedo is to travel. If the torpedo descends below that depth, the water pressure, overcoming the spring pressure, pushes the diaphragm inwardly. If the torpedo is above the desired depth, the springs overcome the water pressure, and push the diaphragm outwardly. The centre of the diaphragm is attached to levers and rods which pass through the tail of the torpedo and act on a pair of horizontal rudders, throwing them up or down, according as the diaphragm is pressed inward or outward, and thus correcting the deviation of the torpedo from the horizontal plane at which it is designed to travel.

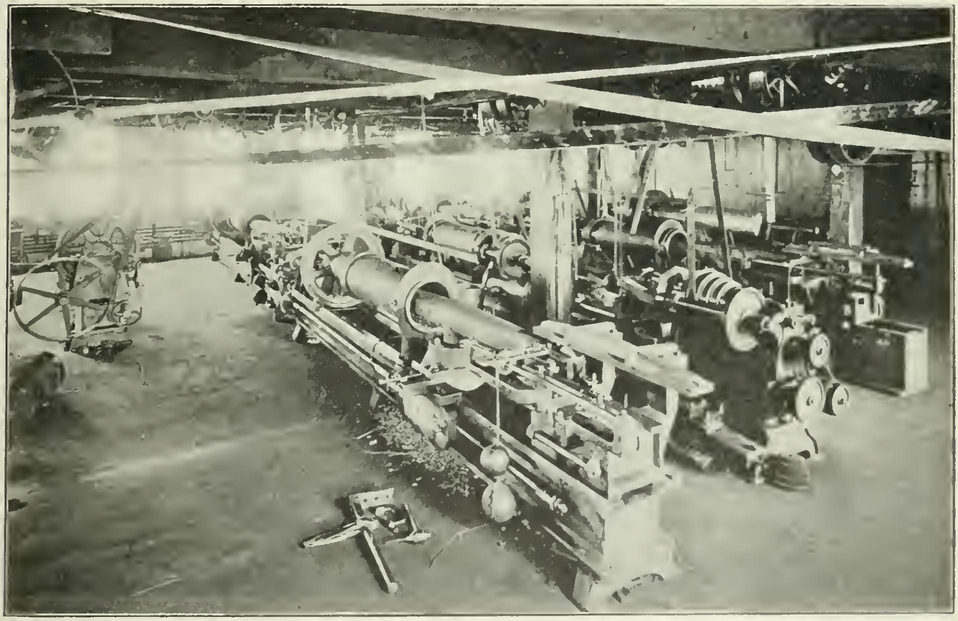


SHOWING HEADS AND FINISHED TORPEDOES AT THE WORKS OF THE E. W. BLISS CO.

Astern of the immersion chamber is located the steering geer. The direction of flight is preserved by a modified Obry gear. This consists of a small gyroscope wheel so connected that any deflection of the main body of the torpedo from the true course is corrected by the action of two small rudders. The action is quick and positive. The gyroscope wheel is a sphere of steel about as large as a baseball, and weighing less than 2½ lbs. It is driven in a most effective and ingenious way. One-half of the wheel spindle is hollow to receive air from the flask. The wheel proper is formed with a series of channels arranged in a central plane vertical to the spindle. The channels are placed tangentially so that the escaping air acts on the principle of the Barker mill. By this means a speed of 18,000 r. p. m. is obtained. If the torpedo tends to deflect to the right or to the left, this gyroscope turbine maintains its original position, and its angular motion with regard to the torpedo (or to speak more accurately, the angular motion of the torpedo about the gyroscope) serves to actuate a mechanism which turns the vertical rudders to the right or left, and corrects the deviation.

Each torpedo is provided with two heads—a practice and a war head. When fired with serious intention the war head contains a charge of 125 lbs. of wet guncotton. This head is formed of two halves, cut longitudinally and brazed together, this joint being made after a saw-tooth pattern. So accurately is this job performed that it is impossible to detect the joint being made after the piece has been finished.

The Bliss Company has perfected a very perfect machine for cutting the buckets of the turbine wheels. These buckets are made integral with the body of the wheel. The machine resembles a double spindle lathe, the work being held on the tail stock. There are two cutters which alternately recede and advance toward the rim of the wheel, which is held in a horizontal position. At the same time the cutters revolve about a common center. One cutter operates on one wall of the bucket and the other on the opposite wall. The result is a bucket perfect in contour and having highly-finished surfaces.

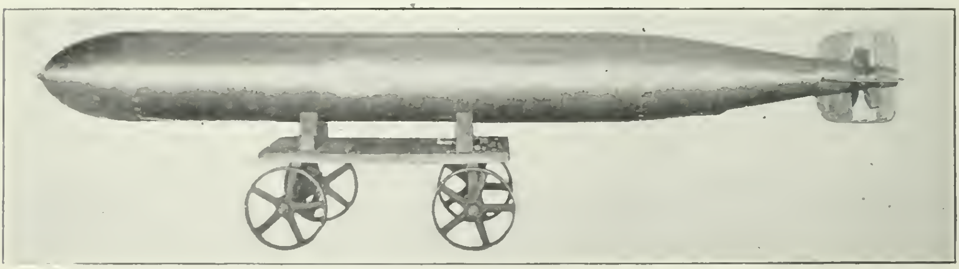


AUTOMATIC MACHINES FOR FINISHING TORPEDOES.

The above particulars are from an interesting account in the U. S. Journal of Artillery, and it will be interesting to see how these torpedoes act on trial.

WHAT THE BUYER WANTS BESIDES SPEED

Apropos of the use of compressed air on a motor-car, there is no reason why one or both brakes should not be operated by this means, says a contemporary, nor why air pressure should not be used to assist the inrush of the mixture at high piston speeds. There is also no practical difficulty in using compressed air for starting purposes, which would be a great boon. The average motorist is now more often than not quite satisfied with the speed of his vehicle, but desires that punctures shall be easily mended, and that the power of his engine should be more variable, so that speed changing should be as rare as possible. Six cylinders, or a low gear, or a light car with a powerful engine, all achieve to some extent this object; but more experiments, having in view the increased flexibility of the engine itself, are much needed. Therefore, good as all these trials and contests are, we doubt whether the buying public is much interested in them, for, as a rule, they merely prove relative power and speed, in which many modern buyers take but a languid interest.



FINISHED BLISS-LEAVITT TORPEDO.

LIQUID AIR.

At the time of the first commercial production of liquid air, several years ago, a number of untenable claims were made as to its practical applications. One of the most valuable uses to which the liquefaction of air has been put is that of the subsequent separation of the oxygen and nitrogen by fractional distillation and rectification. The possession of such a substance as liquid air, however, has proved of much value in the study of the behavior of various materials at low temperatures. It is generally assumed, for instance, that at very low temperatures metals become brittle and even fragile, and in numerous cases, the breaking of steel rails in winter weather has been attributed to this cause. By the use of a bath of liquid air it has been found practicable to test various metals and alloys at temperatures as low as 180°, and this has led to the discovery that while many steels have their tensile strength increased, their ductility lowered and their brittleness raised at low temperatures, this is not always the case. R. A. Hadfield, a well known British metallurgist, has shown that a nickel manganese steel can be made which will be as tough if not tougher at —180° C. than it is at ordinary atmospheric temperatures, and this, too, without material change in the tensile strength. Liquid air has also been used for quenching specimens after tempering, and some instructive information has been obtained about the process of hardening in this way.

HARDENING DRILLS.

Hardening an ordinary drill in sulphuric acid makes an edge that will cut tempered steel or facilitate cutting hard rock. The acid should be poured into a flat-bottomed vessel to a depth of about 1/8 inch. The point of the drill is heated to a dull cherry red, and dipped in the acid to that depth. This makes the point extremely hard while the remainder remains soft. If the point breaks, reharden but with a little less acid in the vessel.

CLEARANCE IN A COMPRESSOR AND ITS RELATION TO VOLEMETRIC EFFICIENCY

By D. W. Hering.

(Concluded from January number.)

(3) With polytropic expansion: The actual expansion curve as traced by an indicator is intermediate between the isothermal and the adiabatic, and nearer the former than the latter. The polytropic exponent n therefore to be used instead of k is between 1.41 and 1. If we could assume that the expansion curve corresponds to that of compression, with water jacketed cylinders, n might be taken at about 1.3. This value in place of k in equations (C) and (H) would determine the volumetric efficiency of the corresponding compressor, and the pressure for which the efficiency is zero. The results in the same cases as above are given in the last column of the following table, in which the volumetric efficiencies are computed to the nearest per cent., for various values of clearance and pressure, assuming the air to be initially at standard barometer pressure.

CLEARANCE C	COMPRESSION RATIO r	GAUGE PRESSURE LBS/SQ. IN.	VOLUMETRIC EFFICIENCY, E		
			ISOTHERMAL EXPANSION	ADIABATIC EXPANSION	POLYTROPIC EXPANSION n = 1.3
0.5%	14.60	200	0.93	0.97	0.965
1.0%	7.80	100	0.93	0.97	0.960
	14.60	200	0.86	0.94	0.930
2.0%	7.80	100	0.86	0.93	0.920
	14.60	200	0.73	0.89	0.860
	51.00	735	0.00	0.59	0.610
	165.40	2417	....	0.27	0.000
	255.60	3733	....	0.00	.....
5.0%	7.80	100	0.66	0.84	0.810
	11.00	147	0.50	0.78	0.730
	14.60	200	0.32	0.71	0.660
	21.00	294	0.00	0.62	0.520
	52.14	752	....	0.22	0.000
	73.17	1061	....	0.00	.....

Some of these pressures are far above what would be attempted in single stage compression; they are given to show the pressure at which the efficiency is low, or in extreme cases the limit at which it is zero, and it is easily seen that to reach a pressure as high as one hundred pounds the efficiency is materially reduced if the clearance is as large as two per cent.

The general equation $E_v = 1 - C\ (r^{\frac{1}{k}} - 1)$ can be applied to any case, with various values of C and r, by making k equal to *1* for isothermal expansion of the air in the clearancee space, or equal to n, (*say 1.3*), in a cylinder partially cooled, or *1.41* for adiabatic expansion. The equation shows that for a given value of C the efficiency decreases as r increases; also the larger n is, the smaller $\frac{1}{n}$ becomes and the nearer E approaches to unity; so that with any given clearance and ratio of compression, the volumetric efficiency is highest if the expansion is adiabatic and lowest if it is isothermal. The figures in the table exhibit this fact also. But it is well known that for compression that is most economic of power the conditions are just the reverse of these.

A reference to the diagram shows that the steeper the expansion curve DG, the larger the intake of air V_x, and consequently the higher the volumetric efficiency. The adiabatic curve from D or D′ descends more steeply than the isothermal (D′I), and if the expanding air not only has no heat supplied to keep its temperature constant in expanding, but actually has some heat extracted from it, the curve might be even steeper than the adiabatic, the exponent in place of k would be greater than 1.41, and this would tend to offset the disadvantage in respect to volumetric efficiency that results from cooling the air while it is being compressed. From this it would seem as if the efficiency might properly be computed for adiabatic expansion, but curves of expansion as actually recorded by the indicator more commonly correspond to a value for n of *1.25* or *1.3*.

From such a discussion several methods of correcting or reducing the loss on account of clearance suggest themselves, which have been used separately or in combination: (a), with a given necessary space for clearance, its proportion to the volume traced by the piston is less the longer the stroke, so that to use as long a stroke as the power will permit is to increase volumetric efficiency; (b), if water injection is used for cooling the air during compression, the water will fill the clearance space at the end of the stroke resulting in a complete discharge of the air compressed; (c), the efficiency is higher with a small ratio of compression than with a large ratio, therefore by compressing in successive stages higher volumetric efficiency is attained than by single stage compression. For instance, referring to the table, with two per cent. clearance, single stage compression to 51 atmospheres delivers about 61 per cent. of air; the same compression in two stages, with r equal to *7.14* in each stage, would have an efficiency of 93 per cent. in each, or a final value of 86 per cent; (d), the air within the clearance space may be provided with a channel so that it does not have its maximum pressure when the piston recedes. At the instant the stroke is completed a by-pass is opened automatically from the small space in front of the piston to the large space behind it. Air rushes from the former into the latter and the pressure in the entire cylinder is equalized, the resulting pressure being, even in high compression, but little greater than that of the atmosphere. Upon the recession of the piston the pressure on the suction side falls to that of the atmosphere and new air begins to enter the cylinder, much earlier than it would if the air in the clearance space had not been reduced in pressure by this equalizing process. The effect of this upon the volumetric efficiency is striking. The treatment briefly offered here follows von Ihering,[*] who has discussed this device extensively and thoroughly, and obtained results that conform closely to those obtained in practice as well as in theory by J. F. Weiss.[**]

Continuing with former notation,

Let CV_a = volume of clearance at either end of cylinder,

and $C'V_a$ = volume of communicating channel past the piston,

Before equalization, $CV_a\ P_1$ = product of pressure and volume of air in clearance on high pressure side of piston,

$(1 + C)\ V_a P_a$ = product of pressure and volume of air on other side of piston.

Let P'_1 = common pressure on both sides after equalization,

then $(1 + 2C + C')\ V_a$ = total volume of air in cylinder, both clearance spaces, and connecting channel, and

$(1 + 2C + C')\ V_a P'_1$ = product of pressure and volume of equalized air.

If the temperature has not been altered,

$$CV_a P_1 + (1 + C)\ V_a P_a = (1 + 2C + C')\ V_a P'_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(I)}$$

Inserting for P_1 its value rP_a, (I) becomes

$$(Cr + 1 + C)\ V_a\ P_a = (1 + 2C + C')\ V_a P'_1$$

whence

$$P'_1 = \frac{1 + (1 + r)\ C}{1 + 2C + C'}\ P_a \ldots\ldots\ldots \text{(J)}$$

$$\frac{P'_1}{P_a} = r' = \frac{1 + (1 + r)\ C}{1 + 2C + C'} \ldots\ldots\ldots\ldots \text{(K)}$$

There can be no serious error in the assumption that the equalization is accomplished with little change from the original temperature, for the waste space is small compared to the volume of the cylinder, and the equalizing is so rapid that the temperature of the air in the clearance on the compression side of the piston falls to practically the temperature of the air on the other side, while that which flows over to the rear of the piston there mingles with a large quantity at low pressure, and does not sensibly raise the temperature of the air with which it thus mixes.

The quantity of new air that will be taken into the cylinder will depend upon whether the action from this stage is isothermal, adiabatic, or intermediate between these extremes.

(1) If expansion after equalization is isothermal: When the pressure is equalized there is the clearance a volume of air CV_a at pressure P'_1. When the piston recedes the air in clearance expands, with pressure diminishing to P_a. It then has a volume $V' \dfrac{P'_1}{P_a} CV_a$. Calling the additional air that will be drawn in as the piston reaches the end of its transverse Vx, and placing r' for $\dfrac{P'_1}{P_a}$, we have $V_a + CV_a = V_x + r'CV_a$, whence

$$E_v = \frac{V_x}{V_a} = 1 - C\,(r' - 1) \ldots\ldots\ldots \text{(L)}$$

(2) If the expansion is adiabatic: As in deducing equation (F), V' now becomes equal to $CV_a \left(\dfrac{P'_1}{P_a}\right)^{\frac{1}{k}}$ and $E_v = 1 - C\left[\left(r'\right)^{\frac{1}{k}} - 1\right]$

$$\ldots\ldots\ldots\ldots\ldots\ldots \text{(M)}$$

(3) With polytropic expansion,

$$E_v = 1 - C\left[(r')^{\frac{1}{n}} - 1\right] \ldots\ldots\ldots\ldots \text{(N)}$$

These last three equations for E_v are like the former ones except that they contain r' instead of r. With a given clearance and compression ratio, r' depends upon the size of the communicating channel relatively to the piston displacement. In the following table C' has been taken equal to 0.01, r' is computed from equation (K), and the volumetric efficiency under equalization of pressure compared with that without equalization. ($n = 1.3$).

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[*] Die Geblaese, II Theil, 4, 5 Kap.

[**] Zeitschrift der Vereins deutsch Ings,, 1885.

C	r	GAUGE PRESSURE	VOL. EFF. WITHOUT EQUAL'N		r'	VOL. EFF. WITH EQUALIZ'N	
			ISOTH'LY	POL'TR'Y		ISOTH'LY	POLYTR'LY
0.01	7.8	100	0.93	0.96	1.056	0.999	0.999
	14.6	200	0.86	0.93	1.122	0.999	0.999
	51.0	735	0.48	0.80	1.476	0.996	0.996
0.02	7.8	100	0.86	0.92	1.101	0.998	0.999
	14.6	200	0.73	0.86	1.250	0.995	0.998
	51.0	735	0.00	0.61	1.943	0.981	0.987
0.06	7.8	100	0.66	0.81	1.300	0.985	0.989
	14.6	800	0.32	0.66	1.600	0.970	0.978
	21.0	294	0.00	0.53	1.900	0.965	0.968

Effective as this method is in increasing volumetric efficiency, it is open to the objection that when the resistance to the piston is suddenly released by opening the by-pass, the compressor is liable to pound at the end of each stroke.

A LIQUID AIR RESCUE APPARATUS

Mr. Otto Simonie, in a paper read recently gefore the North England Institute of Mining and Mechanical Engineers, states that after some years of investigation he perfected the Aerolith, a liquid-air rescue apparatus, which weighs about 14 pounds, is easily carried on the back without any incumberance, and gives an absolutely pure and deliciously cool air supply for up to 3 hours' working. It does not contain any chemicals; it is without complications whatsoever; there is not a single valve in the whole apparatus; and its use does not require any special training.

Atmospheric air, says Mr. Simonis, liquefies at a temperature of —191 degrees C., and is compressed to about the seven-hundredth to eight-hundredth part of its original volume. Consequently 1 gallon of liquid air will evaporate into 700 or 800 gallons of atmospheric air. The principle has been applied to serve the following purpose:

A solid nickel receptacle, well insulated against atmospheric influence, capable of absorbing 1 gallon of liquid air in its asbestos-wool packing, is carried as a knapsack. A face mask, or a miners' mouthpiece, is connected through a double tube connection with this vessel; one tube leading in a diagonal direction through the vessel and thence leading into a double bag at the back of this vessel, serves for the air exhaled, which gives all its heat to the liquid air contained in the vessel, and so evaporates it; and from the top of the liquid air vessel the air evaporated is led through the other tube to the mouthpiece. The second bag is fitted with an outlet for the exhaled air mixed with any superfluous fresh air at overpressure.

Liquid air can be stored in the vacuum vessels designed by Sir James Dewar, and will then, under ordinary atmospheric conditions not lose more than 5 or 10 per cent. by evaporation per day. Even at the present time, when no purely commercial use for liquid air has been unniversally adopted, it can be purchased for 5s. ($1.25) per gallon; whereas it can be produced by small plants at 1s. (25 cents) per gallon, and by large plants at 6d. (12½ cents), 3d. (6¼ cents) or even less per gallon. Liquid air can be transported with absolute safety by rail or car. For central rescue stations or large coal mines, however it would certainly be desirable to erect an air liquefying plant. A plant, requiring about 8 h. p.,producing about one 1 gollon of liquid air per day, and not accupying more than 45 square feet, can be bought for about 400 pounds, ($2,000.)

One of the appliances has been purchased by the British Royal Commission on Safety in Mines for detailed experiments and research, and a large liquid air plant has been erected at Baron de Rothschild's coal mines in Austria, Aerolith apparatus being substituted for all the latest types of mining rescue appliances heretofore used.

COMPRESSED AIR AS AN INSULATOR.

A patent has been obtained by Prof. H. J. Ryan for means of producing extremely high dialectric strength. The conductors are provided with "minor" insulation of the ordinary kind, which immediately surrounds them. The electrical apparatus is mounted in a compartment capable of withstanding an ample pneumatic pressure. Air (or other suitable gas) is then introduced into the compartment under sufficient pressure to cause the density of such gas to rise to and be maintained at a point by virtue of which all air (or gas) confined within the compartment has attained a dielectric strength ample to withstand the pressure to which the electric circuit thus insulated is subjected. For example, it is estimated that at a pressure of 40 atmospheres the dielectric strength of the air should be as great as linseed-oil bond paper, at 18 atmospheres it should be as good as that of micanite cloth and at 8 atmospheres it should equal that of melted paraffin or boiled linseed oil.

sufficient pressure to cause the density of such

COMPRESSED AIR ILLNESS OR CAISSON DISEASE. *

A PHYSIOLOGICAL AND CLINICAL STUDY.

By Thomas Oliver,

M.A., M.D., L.L.D., F.R.C.P.

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In its simplest form, a caisson is an iron cylinder somewhat bell-shaped, open at its lower extremity and closed by sliding doors at its upper. Leading out of the upper part on one side is a chamber called an "air lock" which is separated from the interior of the caisson by an iron door and also from the outside by similar means. It is through this air lock that the men enter and leave the caisson. Between the sliding doors at the upper part or movable ceiling of the caisson and the roof is a chamber or space known as the "material lock" through which the buckets filled with soil are passed. When placed in position, the bell-shaped expansion of the caisson rests upon the bed of the river and atmospheric air under pressure is pumped in. This by displacing the water enables the men to work in a pneumatic chamber wherein they are dependent for the air they breathe upon that delivered into the caisson by pipes from an engine, and as the surplus of air escapes by the bottom of the caisson ventilation is by this means effectively secured. Frequently a caisson is a much more complicated structure than that just described. It may be, as at Newcastle upon-Tyne a large iron chamber not unlike an inverted pudding dish, the roof of which is pierced by two or three shafts, each provided in the upper part with its own air lock and material lock and with its own iron ladder, leading down to the working chamber. In visiting the viaduct works close to the railway station in Amsterdam yesterday I found that the contractors employed the Zschokke lock so that the buckets of soil are removed by a separate lock from that by which the men enter and leave the caisson. This arrangement has much to commend it.

To pass into a caisson the workmen enter the air lock and close the outer door behind them. Turning the cock of a tube which leads from the interior of the shaft and regulating its escape, the man in charge allows air to enter and to fill the air lock and when the pressure in this chamber has come to equal that inside the caisson, the inner door hitherto kept firmly closed by the greater pressure inside the caisson can now be readily opened and the men entering the shaft descend the iron ladder to the bed of the river where the work of excavation is being carried on.

A few minutes are taken up in passing through the air lock. During this period the men are undergoing what is called "compression" and as the rise of pressure ought to be gradual and not too rapid, only trained men should be allowed to work the valves of the air lock. To new comers and men who are entering upon caisson work for the first time the process of compression is unpleasant. Unless the workman has been previously taught to swallow air and pass it up his Eustachian tube into the middle ear, the pressure upon the outer side of his membrana tympani may be so great as to cause considerable pain. In some instances the drum of the ear has ruptured. During compression, the blood keeps absorbing the gases of the air until the tension of the gases therein becomes equal to that of the compressed air. When this equilibrium has been attained there is secured to the workman immunity from immediate trouble. The workman can remain in the caisson and follow his employment for a few hours without experiencing any inconvenience. There are certain things, however, that he cannot do in the caisson. He cannot whistle or shout as loudly inside the caisson as he can outside, but he can work as hard if not harder, he can ascend the iron ladder much more nimbly and with less shortness of breath inside than he could do a similar length of ladder outside the caisson.

When the workmen are coming off their shift they pass into the air lock and close the inner door. A procedure the reverse of that on entering the caisson is now gone through. The men now undergo what is called "decompression." A stopcock attached to a tube which communicates with the external air is turned and the compressed air is allowed to escape slowly. When the pressure inside the air lock equals that of the external atmosphere the outer door is opened and the men step out, enveloped in a thick fog or mist. During the process of "decompression" the cold in the air lock is often intense—there may be a rapid fall of 40° F. of temperature. It is usually after decompression that the symptoms of caisson disease or compressed illness develop. Since symptoms never come on when the men are working in the compressed air but always after they have come out of it, the term "compressed air illness" is somewhat misleading. In small caissons only two or three men may be employed, but in great engineering operations such as the building of the railway bridge at Newcastle-upon Tyne the caissons are very large so that thirty-five men can work in them at one time. On the Tyne the working chambers were 113 feet in length, 35 in width and in height 9 feet 6 inches and their cubic capacity 23,142 feet.

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* Abstract of a Lecture delivered to the "Genootschap ter Bevordering van Natuur-, Genees- en Heelkunde", Amsterdam.

The interior of the caisson was lit by electricity. Inside the caissons the men are employed in shovelling away the soil into buckets which by means of a chain and crane are lifted up through the two sets of sliding doors in the upper part of the shaft, between which is the material lock, and emptied.

From a physiological point of view the air inside the caisson ought to be as pure as possible. Pure air and plenty of it should therefore be pumped into the shafts, and the surplus air should escape readily so that ventilation of the caisson is secured and the presence of gaseous impurities that may have accidentally entered the caissons during the removal of the soil rapidly removed. On passing through certain strata offensive and dangerous gases may be encountered. On the River Tyne this has taken place on two occasions when a layer of soft coal was being excavated. There was an escape of gas, probably H_2S, into the caissons and several of the men became ill. The amount of air pumped into the caissons must be large. Snell, the medical officer in charge of the Blackwall Tunnel, London, found that while the estimated cases of illness for 100 days were 80.9 when less than 4.000 cubic feet of fresh air per man per hour were supplied, and 22.5 when from 4.000 to 8.000 cubic feet were supplied, that the numbers fell to 8.5 when upwards of 8.000 cubic feet of air were pumped into the cylinders. It is generally held that the air requirements insisted upon by Snell are excessive and that what he considered necessary for tunnelling purposes where the excavations were carried on in the horizontal, and where the escape of surplus air was enormous, do not apply to work done in the perpendicular. ?Snell is of the opinion that 9.000 feet of fresh air per man per hour are necessary, but on the River Tyne it has been found that 1.320 cubic feet are sufficient.

Only pure air should be pumped into the caissons. When the engines that pump in the compressed air have been working for a considerable length of time they get overheated, and there is then the risk of the gases formed during the decomposition of the oil used for lubricating purposes being pumped into the caissons along with the air and these render the atmosphere not only disagreeable but dangerous to the workmen. To overcome this a layer of cold water should be made to circulate round the cylinders of the engine so as to keep the temperature low, and only high flash oils 560° F. or thereabouts should be used as lubricants. Since there is always the risk of an engine breaking down, there ought to be at all large works two or three engines ready in case of emergency to pump air into the caissons. The surplus air usually escapes in tremendous volumes from the cutting edge of the bell-shaped part of the caisson as it rests upon the bed of the river, but occasionally the caisson sinks firmly into a bed of clay, whereby the escape of air is prevented. The caisson is then said to be resting upon a "water-tight" stratum, and as no air can escape, it is absolutely necessary there should be safely valves that will act automatically, otherwise the caisson might burst and the results be disastrous. On one occasion such an accident happened in France when all the inmates were immediately killed. Safety valves are therefore placed in the upper part of the shafts close to the air lock, and there are also safety valves on the engine, which cut out immediately the pressure inside the caisson when it has risen too high On the Tyne the safety valves in the shafts of the caisson are so arranged as to act immediately and automatically whenever the pressure inside reaches ½ lb. higher than the maximum pressure the men have been working at for that particular day. If, for example, the men have been working in a pressure of 30 lbs at low tide and 35 lbs at high tide the safety valve in the shaft will act automatically when the pressure rises to 35½ lbs. When the lower portion of a caisson is resting upon a "water-tight" stratum and no air can escape, the arrangements are such inside the caisson that the air can be pumped in by two of the three shafts and by tubes delivered at the place where the men are working, while the valves in the upper part of the third shaft are opened, and thus a circulation of air is effected. Owing to the enormous weight of some caissons and the fact that they keep sinking as excavation proceeds, it is necessary to protect the workmen inside from such accidents as might arise by the caisson tilting over to one side, or by its suddenly sinking into the soil and thus crushing the men. Strong iron girders therefore span the interior of the caisson, and the men are not allowed to work under a girder. In the middle of each girder is a large circular opening by means of which the workmen can pass from one part of the caisson to another. In small caissons, in which only two or three men can work, girders are not required. The caissons on the Tyne weighed 800 tons, and when the concrete is added to them, their weight is 10,000 tons. Since it is the caissons, when filled with concrete and their superadded concrete and masonry which become the piers of the future bridge and will ultimately have to bear such enormous weights as heavily laded railway trains, it is absolutely essential that these caissons should be substantial and that they should rest upon a firm and durable basis. In filling in the interior of the caisson with concrete carbonic acid is given off from the concrete and as the air impregnated with this gas cannot escape by the bottom of the caisson, and the gas, if retained, in the air would be harmful to the workmen in the caisson, provision has to be made for the removal of the gas and the circulation of air by opening the valves in the upper part of one of the shafts.

It is very rarely that accidents happen inside a caisson. Provision however should be made for such a contingency in the form of a sling or other contrivance, whereby injured men could be hoisted to the level of the air lock. As the caissons sink new lengths of iron tubing have to be added to the upper part of the shafts so that the air lock shall always be well above high water level mark. In tidal rivers the pressure inside the caissons rises and falls with the tide. The pressure has to be regulated according to the depth at which the men are working. One pound pressure of air displaces 2 feet four inches of water. Expressed in other terms, 10 metres of water are equivalent to 1 atmosphere. For every 33 feet of water a pressure of 15 lbs. to the square inch or 1 atmosphere is required, to keep the water out of a caisson. When men are working at a depth of 100 feet it requires a pressure of 3 atmospheres or 45 lbs. to the square inch inside the caisson. In making use of these figures it has to be remembered that the amount of pressure stated is the amount over and above that of the normal atmospheric pressure viz: 15 lbs. to the square inch, and which is not included in the amounts stated.

It is after all not such a long march from the diving bell invented by Sturmius at the beginning of the 16th century to the huge caissons now in use, and which are capable of holding 30 to 40 men. On the river Tyne there is a double shift of men, the average number of hours worked is 10¼ per day: viz.

6 A. M. to 8.30 A. M. = 2½ hours
9.15 A. M. 1 P. M. = 3¾ "
2 P. M. 6 P. M. = 4 "

Total per day = 10¼ hours.

The working hours or shifts are, I think, better arranged here than in Newcastle. In Amsterdam I find the men work for 4 hours, are off for 8 hours and again work 4 hours. I also observed with pleasure that the men coming out of the air lock all wore round their shoulders a blanket shawl provided for them by the employers.

HYGIENE OF COMPRESSED AIR.

The influence of compressed air upon man has been an interesting study to the practical engineer, the physicist, and physiologist. At 3 atmospheres it is impossible to whistle, and the voice has a nasal twang. Sounds are not conveyed with their usual intensity. Opinions differ as to whether the men are as easily fatigued. It is generally admitted that they ascend the ladders inside the caisson with greater ease and less breathlessness than they can do outside. American writers have stated that at 40 lbs. pressure taste and smell lose their acuteness, but on this point opinions are divided. The workmen do not hear so well owing to the diminished rate of vibration of the membrana tympani. Owing to the increased velocity of the waves the pitch of the sound is higher. Respiration is slightly increased. Under a pressure of 33 lbs. it may rise to 21 per minute, probably in consequence of a diminished elimination of carbonic acid. If the pulse rate rises it is only for a very short time. In watching the circulation through the web of the foot of a frog subjected to 200 to 300 lbs. pressure, the circulation after the first few minutes seemed to me to proceed without any apparent change. Dr. Andrew H. Smith, of New York, believes that the volume of the pulse is smaller since the compressed air prevents the expansion of the artery, but this would impose more work upon the heart, and thus recovery of the volume would take place. Owing to the saturation of the air in the caisson with moisture, the hard character of the work, and that evaporation from the skin is impaired, there is a slight rise of the body temperature according to some authors. This was not found to be the case in Hill and Macleod's experiments. As the clothing of the men becomes permeated with moisture, and there is a rapid fall of temperature inside the air dock on coming out during decompression the men run the risk of becoming chilled. Working in compressed air is said to improve the appetite. This would suggest increased waste of tissue. Under 4 atmospheres of compressed air Hill and Macleod found in one animal a decided increase in the daily elimination of urea, but not in others. Paul Bert found the amount of urea decreased and Snell no change at all. There is nothing constant therefore about the nitrogeneous waste. The output of CO_2 is diminished. Hill and Macleod exposed muscle nerve preparations of frogs to 50 to 60 atmospheres of oxygen for one hour, when they found the muscle still directly and indirectly excitable. There was no alteration in the latent period of stimulation, nor in the rate of conduction in the nerve. A frog's heart exposed to the same high pressure continued to beat rhythmically for nearly two hours. After decompression the vagus was not found to be excitable owing probably to paralysis of the nerve terminations in the heart.

Exposure to high pressures of oxygen produces convulsions in most animals when in the compressed air chamber, and these may continue after rapid decompression. Convulsions are not so likely to be produced in animals after rapid decompression from compressed atmospheric air, but the respiration may become embarrased, and there may be paralysis or death. With compressed atmospheric air it was found that convulsions did not occur until 12 atmospheres were reached owing to intoxication from the oxygen being too gradual After rapid decompression from atmospheric air animals become convulsed owing to frothing of gas in the heart and nervous system. The convulsions end in paralysis, but after rapid decompression from oxygen the convulsions still continue because the oxygen set free can maintain the life of the tissues. In the decompression of atmospheric air it is nitrogen that is set free. This gas which forms 79 per cent and therefore the bulk of atmospheric air is, when an animal is subjected to compressed air, absorbed according to the law of partial pressures. "Under 1 atmosphere' 100 c.c. of blood dissolve 1.23 c.c. of N_2 : under 4 atmospheres 4.92 c.c. of N_2. The same blood giyes up 3.66 c.c. of N_2 when decompressed from 4 atmospheres to 1 atmosphere. The whole blood in the body of a man weighing 70 kilos would give up 130 c.c. of N_2".

The tissues of the body take up N_2 more slowly but in larger quantity than the blood, ten times as much, hence the danger of too long shifts for men working in caissons. The proof that the gas which is liberated in the blood and tissues after rapid decompression is mainly nitrogen has been proved by the analysis of the gases of the blood obtained from the right heart of a dog which had been instantly killed by the bursting of a caisson Hill found 15.2 per cent. of CO_2 ; 82.8 per cent. of N_2 and 2 per cent. of O_2. Any oxygen set free during rapid decompression of atmospheric air is at once absorbed by the tissues.

SYMPTOMATOLOGY.

When men are undergoing "compression" or are passing through the air lock into the caisson. beyond experiencing unpleasant sensations due to pressure upon the membrana tympani and which can be diminished or prevented by swallowing air and transmitting it by the Eustachian tube into the middle ear, no symptoms arise during this procedure. Nor do the men suffer when in the caisson owing to the fact that the pressure is evenly transmitted to all parts of the body by the fluids of the body It is after the men have finished their work, have undergone decompression and come out of the air lock that symptoms develop. These may show themselves in a few minutes, or not for some time, an hour or more after decompression. It is an interesting fact that the men who work the air lock and the lower sliding doors of the material lock do not suffer from caisson disease. They are exposed to the same pressure as the men inside the caisson, but they have no hard physical work to do. This freedom from compressed air illness on the part of these men raises the question as to how far muscular fatigue is a predisposing cause of caisson disease. There are grades of caisson disease. In the minor forms the men complain of severe pains in the muscles of the limbs and trunk. which they call "bends," and which experience has taught them will disappear if they allow themselves to be "recompressed." Occasionally there is epistaxis and bleeding from the ears. As stated in a previous part of this lecture the symptoms may come on a few minutes after decompression or shortly after coming out of the air lock, or it may be that the workman is on his way home or has reached home and is at a meal, when he is suddenly seized with severe pains, becomes paralyzed or has a bleeding from the nose or lungs. The loss of power usually affects the legs: once developed the paraplegia is for the moment complete. and is attended by retention of the urine, requiring the use of the catheter. In the minor forms of caisson disease the paralysis disappears in a few days or weeks, but in the severer forms it may persist for several months, be accompanied by loss of sensation and also by the development of ulcers on the heels, bedsores on the buttocks and yet the patient may ultimately recover. The skin of the feet and lower part of the legs often cracks and is thrown off in thick flakes.

Occasionally the symptoms come on immediately after a workman leaves the air lock. The man staggers as if intoxicated and he falls. On being picked up by his comrades, he is found to be unconscious, his breathing is embarrassed, sometimes stertorous; his pupils are dilated, pulse rapid and feeble, and the skin cold. Under these circumstances death may occur without consciousness ever being regained. Or it may be that the workman is so enfeebled generally that he is unable to walk, he is found to have become suddenly childish and weak mentally. I have seen men become the subjects of acute delirium and remain maniacal for two to three days. Occasionally the men have complained of loss of part of the field of vision, without any aphthalmoscopic changes to explain the defect, also of diplopia and facial paralysis. The symptoms of compressed air illness may be ushered in by vertigo vomiting or difficulty of breathing, accompanied by cyanosis. The men sometimes become simply timid and hysterical or their complaint is of such an indefinite character that it is difficult to say whether they are not malingering. When the muscular pains are severe. the men are extremely restless. They roll about in agony and can only be quieted by a hypodermic injection of morphia.

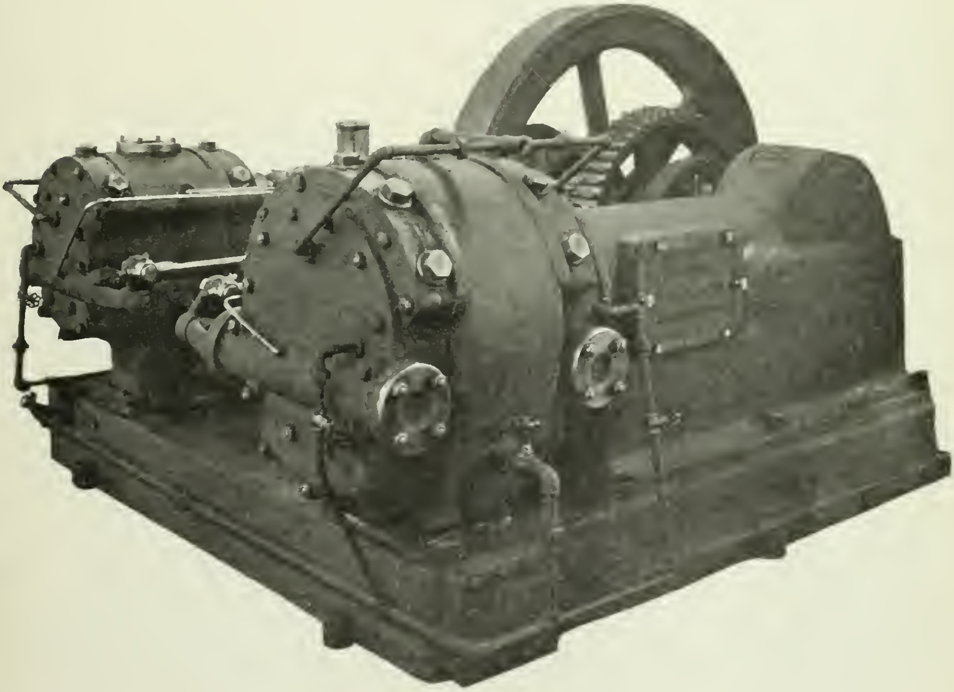
THE PASSING OF THE BROOM

That vacuum cleaners are driving the broom out of use is asserted by a writer in *The Lancet* (London, November 24)' who congratulates the world on the change, on hygenic grounds. He writes:

"The broom threatens soon to be as obsolete as the old copper warming-pan, judging from the number of vacuum dust-removers which are being placed upon the market. The change is one which must meet with the unqualified approval of all who know what a breeding-ground of disease is the common dust of our houses. Every housewife who is possessed of cleanly instincts should welcome an aparatus which removes dust instead of scattering it in all directions. lost to the senses, so to speak for a time by its attenuation in air, only sooner or later to settle again on the shelves, pictures, curtains, and carpets in a thin film. Moreover, the removel of dust and its collection in a receptacle by means of the vacuum-cleaner permit of its absolute destruction by fire. Bacteriological science can easily demonstrate the existence of disease germs in common household dust and there is evidence of an eminently practical character that dust is otherwse a source of disease; there could hardly be a more effectual means of spreading the infective and irritating particles than the old-fashioned broom. The method is not only unsanitary but absurd from the point of view of its aplication. The broom may clean the surface of a carpet, chair. or curtain effectually enough, but the dust is only removed to be scattered elsewhere and to be spread over an even wider area than before. The great and important difference between the cult of the broom and the vacuum cleaner may be summed up by saying that, while the former is calculated to spread disease, the latter enables the dust and its pathogenic contents to be removed and destroyed by fire. The method of removing dust by means of the vacuum cleaner has therefore everything to be said in its favor and it is to be hoped that the apparatus will become so moderate in price as to be within reach of all. The passing of the broom, when it comes, to be *un fait accompli,* will be a fact of great sanitary significance."

A NEW BLAISDELL AIR COMPRESSOR

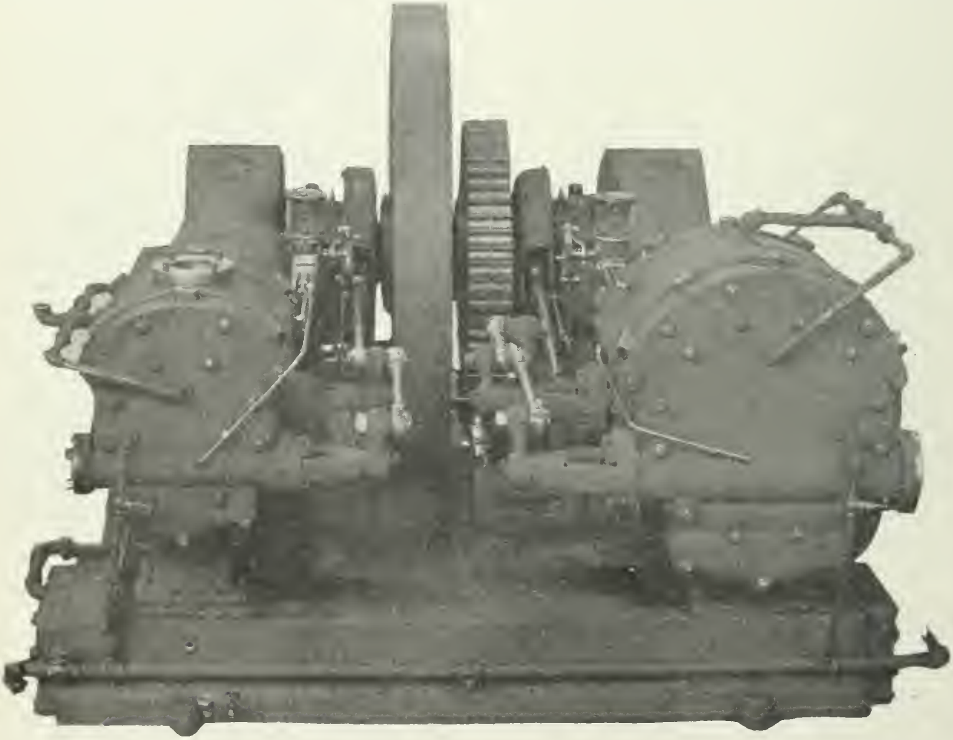
It will probably be of interest to users of compressed air to know of a new self-oiling air compressor which is now being manufactured by the Blaisdell Machinery Company of Bradford, Pa. This company was the first to make a self-oiling machine, and the one here illustrated represents the latest ideas in design and construction of this class of compressor It is known as "Class C" and the machine shown in the accompanying illustration is designed to be operated by an 85 H. P. Westinghouse gas engine. The cylinders are 18 and 12 x 12 and have a displacement of 510 cu. ft. of free air per minute when the compressor is operating at 150 r. p. m.



SIDE VIEW OF NEW BLAISDELL AIR COMPRESSOR.

The frame of the machine is entirely enclosed, allowing the cross-head pin, slides, main bearings and crank pins to run in a bath of oil, which is fed to the parts in copious quantities by the crank discs which dip into the oil chamber. The oil feed to all parts is positive and lubrication starts and stops with the machine without attention. The oil, after being used, drains back to the chamber, around which is cast a raised rib, which the oil must overflow in order to re-enter the chamber, thereby depositing any sediment outside the rim, from whence it may be drawn off. Any drip from the front stuffing box enters and can be drawn off from a separate chamber, preventing it from entering the oil chamber. This inclosed type of frame also thoroughly protects the parts from dust and grit, preventing undue wear and allowing the machine to be located where most convenient Cross head slides are of the bored type, rigidly supported Pillow blocks are of the heavy duty type, well tied into body of frame, the jaws being rigidly held by the interlocking bearing cap On all single compressors these frames are equipped with double bearings to permit of center crank construction.

The compressor is mounted on a substantial cast iron sub-base in which is contained the intercooler, situated directly under the air cylinders. This cooler is made up of a large number of standard brass condenser tubes through which the cooling water passes. Tubes are placed close together, and by means of deflector, or baffle, plates the air is passed between the tubes in the form of thin sheets. The cooling surface is very large and the volume of storage space is ample to supply the high pressure cylinder without causing the air to pass through the cooler too rapidly. The intercooler is entirely self-contained and may readily be removed from the sub-base if desired Furthermore, it is equipped with a safety valve of approved pattern.



REAR VIEW OF NEW BLAISDELL AIR COMPATSSOR.

The main bearings are of a design and construction which is a decided improvement over usual methods. They are of the half-box type, fitted with removable cast iron shells lined with babbitt, which is piened in and carefully bored. Bearing surfaces are unusually large and are so designed that the oil is not wiped off by close-fitting edges. They are adjusted for wear by wedge and screw, the latter being provided with a lock nut.

The cross-head is a steel casting of the box pattern, fitted with removable cast iron shoes, both top and bottom, having large wearing surfaces, and are adjustable by wedge and screw, the bearing surfaces being provided with alternate strips of babbitt metal. The wedge screw is firmly locked, and is relieved of all working strains by two heavy tie bolts which pass through the cross-head body and grip the shoe. The cross-head pin is of the best machine steel, hardened; it is of large diameter and is drawn into the cross-head on a taper being easily removed.

The pistons are cast hollow in one piece and are fitted with re-turned cast iron snap rings, which have a perfect bearing and uniform pressure on the cylinder walls at all points.

The air cylinders are cast in one piece, both cylinders and heads being thoroughly water jacketed. They are fitted with Corliss air inlet valves and poppet outlet valves; the Corliss valves being contained in the cylinder heads which have separate water jaekets from the barrel.

The weight of the compressor shown in the accompanying illustrations, machine and sub-base complete, is 16,500 lbs.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., Assoc. Am. Soc. M. E., Managing Editor
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PUBLISHED BY
THE KOBBÉ COMPANY,
108 Fulton St.,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 108 Fulton St., New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. FEBRUARY, 1907. No. 11.

TEN months ago we notified our readers of a change in management and of the removal of our offices to 90-92 West Broadway. It now becomes necessary to announce another change in address, our old offices having become entirely inadequate to accommodate the new members which we are adding to our staff.

The past ten months have witnessed a remarkable growth both in the number of our subscribers and in the number of advertisers. But, more important than either of these, is the fact that COMPRESSED AIR is meeting with the approval of its old subscribers as evidenced by the small number who have discontinued their subscriptions and the large number who have written us complimentary letters and promptly enclosed the subscription price for another year.

This is particularly gratifying to us as we are endeavoring with all the means at our disposal to produce a magazine which will correctly chronicle every phase of the application of compressed air to modern industrial requirements. But in order to do this adequately, it is necessary that our readers co-operate with us by informing us of interesting and valuable uses for pneumatic power which their experience may have developed. It is only by thus interchanging ideas that COMPRESSED AIR may serve its readers to their mutual benefit.

THE ART OF CUTTING METALS

Probably one of the most important papers ever presented before an engineering society was the one read before the American Society of Mechanical Engineers at its last annual meeting, December, 1906, on "The Art of Cutting Metals," by Mr. Frederick W. Taylor, retiring President of the Society. While this paper would be obviously out of place if reprinted in COMPRESSED AIR, we do not feel that we can let it go by unnoticed, as we have no doubt that many of our readers will not only be glad to know of it, but will be able to profit to a great extent by the information which Mr. Taylor has compiled.

Mr. Henry R. Towne, in commenting on this paper, says: "Mr. Taylor's paper on 'The Art of Cutting Metals' is a masterpiece. Based on what is undoubtedly the longest, largest, and most exhaustive series of experiments ever conducted in this field, its summary of the conclusions deduced therefrom embodies the most important contribution to our knowledge of this subject which has ever been made. The subject itself relates to the foundation on which all our metal working industries are built."

"About sixty years ago American invention lifted one of the earliest and most universal of the manual arts from the plane on which it had stood from the dawn of civilization to the high level of modern mechanical industry. This was the achievement of the sewing machine. About thirty years ago American invention again took one of the oldest of the manual arts, that of writing, and brought it fairly within the scope of modern mechanical development. This was the achievement of the typewriting machine. The art of forming and tempering metal tools undoubtedly is coeval with the passing of the stone age, and therefore in antiquity is at least as old, if, indeed, it does not outrank the arts of sewing and writing. Like them, it has remained unchanged from the beginning until nearly the present time. The work of Mr. Taylor and his associates has lifted it at once from the plane of empiricism and tradition to the high level of modern science, and apparently has gone far to reduce it almost to an exact science. In no other field of original research, that I can recall, has investigation, starting from so low a point, attained so high a level as the result of a single continued effort. * * * The title of Mr. Taylor's paper does scant justice to the scope of the work which it records, for incidental to its main purpose this work included subordinate investigations hardly less radical, even if of less importance, than the main issue. Chief among these was the development of what is now best known as the 'Taylor System' of shop management, itself a discovery of fundamental importance, the influence of which will be felt ultimately and permanently, not only in the metal trades, but probably in all organized industry."

An instance of the efficiency of the Taylor System is cited by Mr. Calvin W. Rice, Secretary of the Society, who stated that he recently had the opportunity to visit the Sayles Bleacheries, located near Pawtucket, R. I., where the Taylor System is being introduced. He was permitted to compare the record of the output of certain rooms before they began to introduce the system and after it was put into operation, and these records showed that even in the most simple matters, namely, folding cloth, the increase in output was very great, individual cases five-fold, and the increase of individual wages 20 to 40 per cent., the cost per piece being materially reduced.

Improvements in other bleacheries have of course been going on all this while, so that the Sayles have no monopoly in this regard, but what they do have over their neighbors is a better class of employees, with higher individual wages, freedom from labor difficulties, because the Taylor System does not conflict with the bulls of labor unions, and, more than all, an organization capable of indefinite expansion to meet any emergency.

While we regret that we are unable to reproduce this paper in Compressed Air, we take pleasure in informing our readers that it is being reprinted in full in the *Iron Trade Review,* and those who are interested in the subject and who do not have access to the Transactions of the American Society of Mechanical Engineers will derive much benefit from reading the paper as it comes out in serial form in the above-mentioned periodical.

We regret to announce the death of Mr. James Clayton, who died at his home in Brooklyn, N. Y., December 31, 1906 at the age of 85 years. In the December number of Compressed Air we were privileged to reproduce a photograph of Mr. Clayton and to publish an account of his achievements. He was born in Shropshire, England, and came to this country in 1849, going to Nevada, where he was successful in gold mining operations. In 1864 Mr. Clayton began manufacturing water and other pumps in Brooklyn. He invented many kinds of pumps and mechanical processes, the best known invention being the air compressor which bears his name.

MACHINISTS ARE WELL PAID.

In every factory, mill, shop, pressroom, power room, everywhere that complicated machinery is in active use, the machinery expert has been needed and supplied, says the Chicago Tribune. From the water pump in the basement of some Chicago skyscraper to the gangsaw in a country sawmill, from the diepress in some sweat shop to the ore crusher in an Alaska gold mine, is the range of the machine expert. His is the hand that effects the direct marvel of the machine, whether its mission be to cut out cap or hat patterns or 12-inch building timbers, whether it be to supply water to a city building or eat up the rock of half a mountain side. Kipling has sung the song of men in many mechanical lines of endeavor, but he overlooked the craft that would have been most prolific of inspiration—that of the machine expert.

That part of Chicago which lies just across the river on the west side and is known as the machine district is the habitat of the machine expert in Chicago. Here he originates. In the factories, shops, salesrooms, foundries, offices of this dark, machine-filled section he learns his trade. Here also he is employed. From here he may be sent to almost any part of the world where machinery is used to put into practice the knowledge gained in the vicinity of Jefferson street, Chicago. There are several hundred kinds of him, just as there are several hundred kinds of machines that he is master of.

His age runs from 22, which is the age of the near genius in the craft, to 72, when he is a veteran of fifty years' experience, grayheaded, spectacled, bowed and efficient. There is a man with a crooked spine who draws $80 every week he works because he and he alone in a force of a score of employes knows just how a new wool carding machine should be set up, and he can do the work with his own hands. His crooked back doesn't hurt him, either, in the opinion of his employers or his employers' patrons. He can make the machines that his firm sells "run." It wouldn't make any difference if he was bereft of his hands and did the work with his toes; the thing is, he does it. Incidentally, he got his crooked back through breaking in, or rather trying to break in a new man in the trade. The apprentice turned on the power before the last nut was tightly screwed on. So one of the many pieces of the machine, operated at a speed of 200 motions an hour, tore loose and struck the expert. He was incapacitated for two months, and his firm lost much money because of it.

The machine expert is a specialist. This is an age of specialism, and nowhere is specializing carried on to such a fine point as in the world of machinery. So intricate are the workings and purposes of many machines that to thoroughly master one is often the work of a lifetime. In the largest and most complicated of machines it is not unusual to find several specialists necessary to its proper erection and operation, one having been unable to achieve proficiency in the whole. In such cases each man is a specialist in his part, and just as a surgeon may be an expert in cranial operation and know little about the sucessful treatment of appendicitis, he may know no more about the machine as a total than is necessary to his own special part. But in most cases some expert, who may or may not have a gang of skilled workmen under him, is responsible for the machine.

The expert invariably is exployed by the makers or selling agents of a machine. In some instances the purchaser of a machine pays the cost of setting it up, but the most usual course is to sell it on condition that the seller put it into operation. It all amounts to about the same, the man who buys is of course the man who pays. So with a $2,000 machine sold in Michigan may go a $50 per week machine expert. His services may be required for a week, it may be but a day. But whatever the time, he stays until he has seen the power turned into the machine, has seen it turn out the work for which it was made and until the purchaser is satisfied that he is getting what he is paying for. Then he packs his grip and hastens back to Canal street, possibly to be sent to Nebraska the next day on the same kind of errand.

Sometimes the expert is salesman as well. In that case he looks after the delivery and running of the machine he sells. Sometimes he is a partner of the firm, for a thorough knowledge of the machinery handled by a house is a pretty good sort of recommendation for a partnership. But in most cases he is just an expert, paid for setting up machines. In the larger houses this is his function exclusively; in the smaller ones, where his services are not continually required in such work, he is employed in the shop, store or office when not employed at his regular craft. Or he may be busy repairing machines when not actually setting them up.

Usually he begins as an apprentice in the shop. Then he becomes a full-fledged workman, and it is then that he shows that he is of the stuff that makes experts or does not. He usually attracts attention by showing that he knows more about the machines made in his shop than his fellow-workmen. Although the mechanic is a skilled and intelligent workman, the man who knows the workings of a machine of which he makes perhaps one part is the exception.

It is from the pick of these exceptions that the machine expert comes.

A few are graduates of technical institutions but the majority have come up from the ground, beginning by running a machine that made a minor part of the machine which afterward they will know so well as to be able to make one if given time. This is just what the expert must be able to do. If he does not, he can not successfully prosecute his work. He must know how every part in his machine is constructed, what its strength, how it shall be adjusted, how it shall run and how the whole shall run when put together. In making repairs he frequently makes with his own hands delicate parts. He is in reality the professor of mechanics; he knows how it all is done and why.

His salary may vary from $20 to $100 per week. If he is exceptionally good he will get the latter figure; if exceptionally poor the former will be his price. His position varies as machines and firms vary. In the best and largest he is a person of importance; in the smallest he is just one grade above the common workman. He occasionally suffers financially during times of industrial depression and sometimes he is worked to death on hurry orders. Generally he can't keep himself continually employed and his vocation is not more crowded than other vocations where brains and special talent are necessary.

NEW PUBLICATIONS

Self-Propelled Vehicles, a practical treatise on all forms of automobiles, by James E. Homans, A. M., 5th Revised Edition, entirely rewritten. 598 pages, with 500 illustrations and diagrams. Published by Theodore Audel & Co., 63 Fifth Ave., New York.

As an introduction to the more important parts of the work the author gives a brief history of the motor car, after which he takes up the subjects of transmission of power, stearing gear, theory of the gas engine, carburetters, gas engine design, etc. In all these parts the author has emphasized the practical aspects of motor vehicles of all powers, confining his space to the discussion of matters fundamental in construction and management.

The book is not confined to the subject of gasolene automobiles, but treats of electrical and steam vehicles with equal thoroughness. Recognizing, however, that the gasolene motor car is the typical automobile of the present day, considerable space has been devoted to a complete discussion of its theory and operation, and an extended chapter on "Gasolene Engine Management," the latter covering, virtually, all forms of difficulty liable to occur under service conditions is included. Anyone reading this chapter can derive an intelligent conception of the requirements of an expert driver, and will find numerous points of information, usually obtainable only by a long and varied experience.

All subjects are most adequately illustrated and we should think the work admirably suited as an educational treatise for owners and drivers of automobiles as well as for those interested in the manufacture and design of these vehicles.

TRADE PUBLICATIONS

Wendell & MacDuffie, 26 Cortlandt St., New York—Catalog No. 16. 24-pages, 4x9 describing Reinforced Corrugated Asbestos Sheathing, which is now being used extensively as a substitute for corrugated iron for roofing and siding of power stations, carbarns, train-sheds, elevators, rolling mills, and similar structures of medium cost, or any building for which corrugated iron has heretofore been used. The catalog also covers the subjects of "Century" Asbestos Shingles, Asbestos Bus Bar Compartment Doors, various methods of laying shingles, etc. Accompanying the catalog is a handsome colored supplement illustrating the exact appearance of the above materials.

Sprague Electric Company, 527 West 34th St., New York.—Booklets describing Electric Hoists and Cranes, Electric Motors for driving ventilating fans and blowers, Flexible Steel Armored Hose for steam and compressed air.

Ingersoll-Rand Company, 11 Broadway, New York.—Catalog No. 36, devoted to Ingersoll-Sergeant Air and Gas Compressors. This book contains 184 pages, covering the complete line of Ingersoll-Sergeant Compressors, a very brief description of each of the nine classes being given, followed by tables of sizes, capacities, weights, etc., with illustrations of typical machines and representative plants. An unusual feature of this publication is the number of actual illustrations of machinery covering almost every line of industrial activity. Two very important articles of an engineering character are included. The first of these deals with "Some Important Elements of Economy in the Straight Line and Duplex Types of Compound Air Compressors," and the other is on "Compound Air Compression," and goes exhaustively into the details of this important subject.

Catalog No. 91, describing the Davis Calyx Diamondless Core Drills, for prospecting mineral lands and for bridge, sewer, or subway soundings and for drilling artesian wells. This catalog contains 62 pages of thoroughly illustrated text matter and goes into the subject in great detail.

Crandall Packing Company, Palmyra, New York.—Catalog, 6x9, describing Crandall Packings for all classes of service. This book contains 80 pages, is fully illustrated, and gives the price per pound of each class of packing, as well as prices on rubber belting, leather belting, steam and water hose, gage glasses, etc.

Sullivan Machinery Company, Railway Exchange Bldg., Chicago, Ill.—Catalog No. 55, 158 pages, 6x9, containing a full account of the advantages of their Diamond Core Drills for prospecting and well drilling. There is also given much valuable information on the cost of diamond drilling, prospecting by contract, records of performance, etc.

Harris Air Pump Company, 62 Lombard St., Indianapolis, Ind.—Small booklet, stating the advantages of the Harris Air Pump Company's system for lifting water from deep wells.

The Dayton Globe Iron Works Company, Dayton, Ohio.—Tables of Power of the New American Turbine, covering the Balanced Flutter Gate, Cylinder Gate, Wicket Gate and New American High Head Types, as manufactured by this company. These Turbines are designed for water power, and the booklet contains much valuable information regarding weirs, velocities of water, discharge of water, and other data of value to users of water power.

Hanna Engineering Works, 820 Elston Ave., Chicago, Ill.—This concern is issuing a bulletin describing two new styles of riveters which they are just placing on the market. One is particularly adapted to boiler and tank work, as it is made in almost any reach, gap and pressure. The other machine is a special lattice riveter for doing work in very close quarters. Another bulletin issued by the above company is one describing the Hanna Radial Reamer for reaming rivet holes after punching.

The Ridgway Dynamo & Engine Company, Ridgway, Pa.—20-page illustrated bulletin describing the McEwen Engine. The bulletin describes the construction of the engine thoroughly and contains many tables on horse-power of different size cylinders and for various cut-offs.

TECHNICAL PUBLICITY ASSOCIATION

At a recent meeting of the Technical Publicity Association, at the Aldine Association Rooms, 111 Fifth Ave., New York, the subject of "The Value of Circulars and Printed Matter" was taken up. Mr. Frank Vreeland Art Editor ot the *American Printer,* spoke of the commercial value of beauty in typography and Walter Gilliss, President of the *Gilliss Press,* New York, made some remarks about limited editions.

The companies represented at the dinner by members of the Association, which is confined to those connected with the advertising departments of machinery manufacturing industries, were as follows: Ingersoll-Rand Co., F. R. Almond Mfg. Co., Pope Mfg. Co., H. W. Johns-Manville Co., Yale & Towne Mfg. Co., John A Roebling's Sons Co., American Locomotive Co., General Electric Co., Patterson, Gottfried & Hunter, New York Edison Co., M. H. Treadwell Co., Crocker-Wheeler Co., A. S. Cameron Steam Pump Works and the Lidgerwood Mfg Co.

The meeting developed into an "experience meeting," and many of the members told of their methods and results with printed matter and circular letters. As usual at the monthly meetings, several new members were elected.

COMPRESSED AIR is in receipt of several very attractive miniature catalogs from the A. S. Cameron Steam Pump Works, and we are informed that these catalogs are printed in numerous languages. The English edition, from the cover view, represents an oak board with panels in gun metal effect, having the oak leaves intertwining the acorn-shaped air chamber of the Cameron pump.

These descriptive catalogs are replete with information and prices regarding the types of a score of pumps in general demand, half-tone illustrations and sectional cuts being used to illustrate the mechanism.

MR. Francis F. Coleman, formerly with the Westinghouse and Allis-Chalmers Comanies, and recently with the Taylor Eng. Co., has joined the Lidgerwood Mfg. Co. as Publicity Manager. Mr. Coleman was at one time Editor of the *Electrical Age,* and is the author of several publications of note, among which might be mentioned "The Book of The Four Powers" and "The Power of the Subway." Mr. Coleman was the organizer of the Machinery Club, and was active in bringing about the organization of the United Exhibitors' Association, at the Louisiana Purchase Exhibition, where he represented the Allis-Chalmers Company. He is a member of the Technical Publicity Association, and brings to his company a large amount of experience as well as an interesting literary style acquired during many years of service with the *New York Press* and other metropolitan newspapers. Mr. Coleman's headquarters are at the main office of the Lidgerwood Mfg. Co., 96 Liberty St., New York.

CASSIER'S MAGAZINE

Cassier's Magazine has been sold by the estate of the late Louis Cassier to Henry Harrison Suplee, for many years the technical editor of the *Engineering Magazine,* and James Van Vorst Colwell, recently works manager for the C W. Hunt Company, and the pub lication will be continued, as heretofore, by the Cassier Magazine Company, 3 West Twenty-ninth street, New York. The editorial conduct of the magazine will be in the hands of Mr. Suplee, who brings to this work a wide experience, both in the practice of mechanical engineering and of technical journalism, while the business department will be directed by Mr. Colwell. The first issue of the magazine under the new management was the January number.

LUBRICATION

The proper lubrication of mine-car wheels and machine parts at a colliery is a most important consideration, and it is probable that few other individual factors so directly affect the cost of production per ton. It is not logical to economize in the various small items of operation and neglect so important an action as the proper lubrication of cars and machinery. One authority claims that about one-half the power expended in mill or mine is lost in overcoming the friction of lubricated surfaces. He also adds that by changing from a poor to a good lubricant the loss is cut to one-fourth the power expended.

It is impossible to give any fixed rules regulating the selection of a proper oil for mine lubrication; however, it is generally believed that a dark-colored oil is of greater value than one that has been filtered to a red or yellowish color, for the process of filteration is not only expensive, but removes a considerable percentage of the lubricating value. Oil of a free-running nature is best for engine bearings, as it reaches the parts more quickly than oil of a sluggish nature. Where the bearings are open and the oil is applied direct, oil of a ciscid nature is more suitable.

The waste incurred in the lubrication of mine cars is hard to avoid when old-fashioned car axles are employed, and this fact makes the buyer hesitate before adopting an expensive oil. Such action is not economy after all, and although some expense is incurred when mine cars are equipped with a self-oiling arrangement, where the oil is supplied from a reservoir in the axle or better still in the web of the wheel, still the eventual saving in power and decrease in wear and waste will more than balance any expenditure.

To the Editor of Compressed Air:

Dear Sir—We wish to call your attention to an error in statement of fact, which occurred in your "Chippings" (I think that is the name) in the December number. The paragraph referred to states that the deepest bore hole in the world, some 5,950 ft., was recently bored in Germany.

There are at least two holes deeper than this. One of these, which was bored in the Transvaal, by John Schanke, an American contractor, to reach the Rand gold formation, was completed this year. A Sullivan Class P machine was used. This hole is 6,340 ft. in depth, and the size of core extracted ranged in diameter from 2 in. at the top to 1⅜ in. at the bottom.

The deepest hole of which we have any record was bored in Silesia, several years ago, and is some 6,700 ft. deep. We believe that this hole was also bored by a diamond drill, although it was not of American make.

If you care to take any further notice of this matter, the above may be interesting.

Yours very truly,
Sullivan Machinery Company,
(Signed), S. P. King.

To the Editor of Compressed Air:

Dear Sir:—Referring to your October issue of Compressed Air, and the article written by Edward F. Schaefer, M. M. E., on Vacuum Peculiarities, I wish to call yaur attention to one or two general statements that do not apply to high vacuums.

Referring to page 4214, he states: "The Compressor Cylinders, when employed for purposes of producing vacuum, are seldom water jacketed. A jacket is hardly necessary, since the air which is compressed, although it has the same temperature range as when compressed under corresponding ranges above the atmosphere, has less capacity for heat, due to its rarefied condition. This lack of heat capacity of air under pressure, below normal, obviates the use in most instances, of intercoolers for "two stage compression." While for low vacuums this is probably true, but when working with vacuums above 27 degrees of mercury, is is absolutely essential that the cylinders be thoroughly water jacketed, in order to maintain proper lubrication. It is also desirable that the intercooler be used in two stage machines for high vacuum service. If water jackets are not employed, it takes but a very short time for the temperature of the cylinder to reach the point where it vaporizes the lubricating oil, which, when mixed with the incoming air, forms an explosive mixture that is sure of ignition, if the vacuum pump is allowed to run for any length of time. It would seem that this might not be expected, because of the low heat capacity of the air at this low pressure, however, the above is the experience of many installations, using high vacuums.

Yours very truly,
Charles H. Hillis.

DOORS TO OPEN BY AIR

In connection with the improvements which George S. Rice, chief engineer of the Rapid Traisit Commission, hopes to provide for the new subways, authority was obtained from the commission for pipe galleries along the routes of the new lines in Manhattan. Mr. Rice got permission to include in the specifications a clause which will call for cars without platforms but with doors about one-quarter of the length of the car at either end. These doors are to be opened by compressed air.

The remarkably simple and sensible suggestion is made at New York that the streets of the city be cleaned by pneumatic machines which would suck the dust into hoppers. Machines of this kind are used in Germany, and their employment in the United States should not be long delayed. Most cities are in especial need of intelligent street cleaning of this kind. The heavy streets cars and the whirling wind stir the dust into the air until the people are compelled to breathe day after day the germs from the street debris.

INDUSTRIAL.

BIG CONTRACT AWARDED

The Pennsylvania and the Baltimore and Ohio Railroad Companies, recently, jointly awarded the contract for the interlocking and signalling of the terminal station being built at Washington, D. C., to the Union Switch and Signal Company of Swissvale, Pa. The installation will be electro-pneumatic, similar in general characteristics to that in the yards of the Pennsylvania at the Union station in Pittsburg. The Washington installation, however, will be the largest and most complicated signaling and interlocking system ever constructed in the world.

The largest one previous to this was put in service at St. Louis at the beginning of the World's Fair, and previous to that the most important was the electro-pneumatic interlocking system at the terminal of the Boston South Station. Both plants were also installed by the Union Switch and Signal Company.

Work in connection with the terminal improvements at Washington is progressing rapidly and is about completed.

THE Traylor Engineering Co., of New York has entered into a contract where by Shirley and Grant, of Reno, Nevada, become exclusive representatiives of that house for the State of Nevada, for the sale of their machinery for mining, sampling, rock and ore crushing, milling, cyaniding, amalgamating, smelting, refining, fuel briquetting and completed.

A close relationship has been established under which the two houses will co-operate in designing and building entire plants, as well as in the sale of individual prices of machinery. Shirley and Grant are well known in the Nevada territory, both as a firm and as individuals, and they have many friends among the mining fraternity.

The Foundation Company of New York is engaged in sinking a shaft at the Syracuse mine of the Missabe iron range. The method used is entirely new on the range and is similar to that adopted in sinking caissons for buildings in the large cities The work of concreting the walls of the old shaft at the Syracuse down as far as the water level has been completed. A roof of concrete is now being constructed across the shaft at the water level. Through this roof is set a section of air tight circular steel shafting through which compressed air is admitted to the workmen below the roof and through which the workmen will descend and ascend to and from their work. The steel shafting will be built in sections to the top of the shaft and capped with the section that contains the trap doors through which the men enter and leave the shaft.

Much difficulty has been experiences in sinking a shaft at this property, but within a short time the contractors hope to have the shaft bottomed in ore. The company has installed an air compressor of 400 horse-power, capable of developing a capacity of 1,600 cubic feet per minute, a receiving tank, a smaller compressor with engine for operating same.

THE LITTLE GIANT CORNER DRILL

The Chicago Pneumatic Tool Company Fisher Bldg., Chicago, announces that they now have ready for the market a new "Little Giant" Drill for corner work. From past experience in air-tool practice the company claims to be justified in the statement that this drill surpasses any other drill for drilling in close quarters, and in corners particularly the machine having been designed especially for work of the latter class. The parts for the No. 4 Little Giant Drill interchange with the new drill, thus insuring quick repairs.

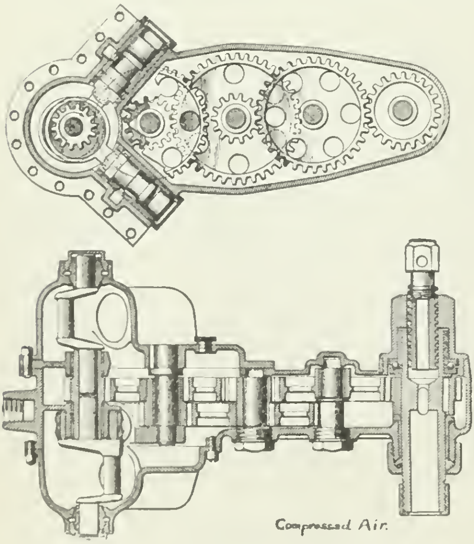


FIG. 1. CHICAGO CORNER DRILL.

This new tool weighs but 35 pounds, has a nominal capacity for drilling 1½-inch holes, but in emergency will drive 2-inch twist drills with satisfactory results. The spindle speed, when running light, is 150 R. P. M., and under load, with 80 pounds air pressure, 100 R. P. M. The distance from the end of the socket to the end of the feed screw, when run down, is 5⅞ inches, the length of feed 2 inches, and the distance from the centre of the spindle to the outside of the housing 1 5-16-inch.

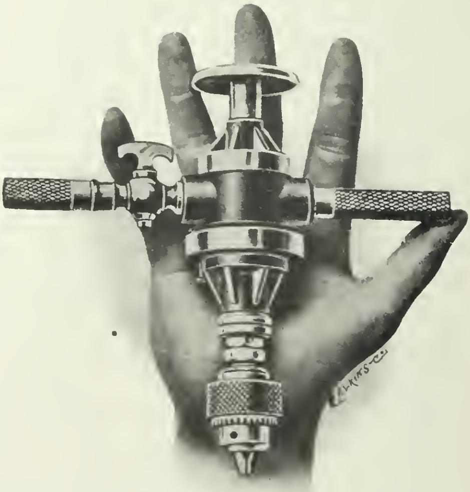


FIG. 2. CHICAGO MIDGET DRILL.

According to the claim of the builders, in addition to being the most powerful drill ever built, weight considered, it possesses advantages over other designs of corner drills, owing to the spindle being driven by gears instead of by ratchet and pawl, which insures steady and constant spindle movement.

The accompanying illustrations give a clear idea of the construction of the drill and its neat and compact appearance. An exterior view of the drill as shown in Figure 3 and Figure 1 gives a sectional plan and sectional elevation which bring out all the important differences between this drill and the Little Giant drills previously manufactured by this company, so that further description is unnecessary.

The air motor movement and the handle controlling the inlet of air are unchanged, in principle at least, but where the drill spindle would normally occupy a position in line with or not more than once removed from the motor shaft, three intermediate gear shafts are interposed. This gives an excellent opportunity for locating the speed-reducing gears in a convenient manner, and generally compacting the construction, so that the entire machine is of short length taken in the direction of the axis of the spindle. The case is oil-tight, to hold lubricant for motor and gears.

The Chicago Pneumatic Tool Company are also placing on the market a most unique air drill known as the "Chicago Midget" (rotary drill), shown in Figure 2, which is designedfor drilling up to and including 3-16-inch holes in steel. The weight of this drill is only 2½ pounds, distance from the top of breast plate to end of spindle 7⅝ inches, distance from the center of spindle to outside of housing 1 inch, motor speed 22,000 R. P. M., and spindle speed 2,000 R. P. M.

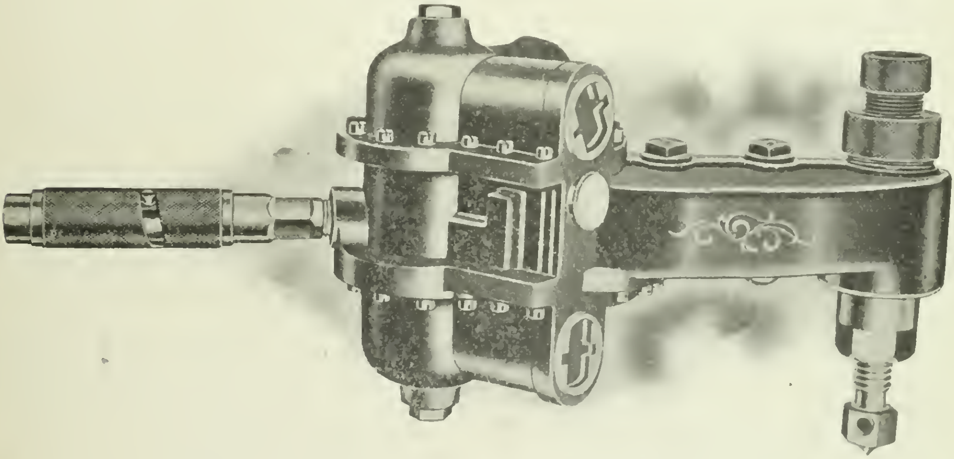


FIG. 3. EXTERIOR VIEW OF LITTLE GIANT CORNER DRILL.

AIR CONTROLLED MOTOR CAR

Air brakes have long been in use on every railroad in the country. They were adopted because of their proven efficiency and their demonstrated superiority over any form of hand brake. The power of an air brake is far in excess of a hand brake. It can be operated with no trouble, no effort. So, when a year ago it was announced that the Northern Motor Car Company of Detroit had under construction an air-controlled motor car, keen interest and curiosity as to the outcome pervaded automobile circles.

Compressed air is applied to the clutch of Northern Model "L" by means of an air compressor operated by the motor. Air is conducted through a hollow crank shaft to the hollow centre of the flywheel, which contains a steel clutch disc between two leather diaphragm discs. A movement of a lever on the steering column admits compressed air to the centre of the clutch at a pressure of about 75 lbs to the square inch, an aggregate pressure of about three tons and engages the clutch instantly and yet without any jerking and jarring. When the car is started on the high speed not the slightest change is felt by the driver or passengers. The air clutch is an extremely simple affair and consists of the three main parts before described. It is claimed and a 10,000-mile test is back of the claim that the car can be run through an entire season without a single adjustment of the clutch. The clutch being housed in the flywheel, in an airtight compartment, is oil retaining and no dirt or dust can get in. This feature alone makes strong appeal to the motorist who knows—who has had experience in adjusting the clutch.

CHIPPINGS.

THE Piqua Blower Company of Piqua, Ohio is being incorporated under the laws of Ohio, with a capital of $50,000. This corporation will take over the interests of the Piqua Foundry and Machine Company of Piqua, Ohio, and will make a specialty of the manufacture of positive blowers and gas exhausters as developed by the later company in the past two years. As the machinery of the latter firm has met with great success, it is necessary to effect this reorganization in order to take care of the large volume of business offered.

SUCCESSEUL ADOPTION OF COMPRESSED AIR.

The Balfour Quarry Co. is successfully employing compressed air in creating artificial bed seams in its Pink Granite Quarry, near Salisbury, N. C. Up till recently it has been supposed that the compressed air method could not be used on this granite, which is exceedingly close grained and compact. The beds so created are level and smooth. Recently a block containing about sixteen thousand cubic feet was detached with remarkably little waste.

AN INTERESTING PISTON PACKING

For steam and gas engines, pumps, air compressors, &c., a novel form of piston packing is made in Glasgow. It consists of three rings the two outer ones being the packing rings proper, while the inner one is the tension ring. This has about double the amount of spring power possessed by the other two, and its construction is such that it does not touch the cylinder walls, its pressure being transmitted to the other two rings instead. It fits them at such an angle that the resultant side pressure tends to lock the bearing rings in the groove, and thus produce a semisolid piston. In this way it avoids the defect common to steam-set packing rings, of wearing the cylinder bore large at the ends, where the steam pressure is greatest. For steam, the packing is made of a special cast iron, and for water pumps of a special bronze. The construction is simple, being straight lathe work, with no hand fitting required. This packing is particularly recommended for use with superheated steam at high piston speeds.

In the operation of air compressors the best results are obtained, it is said, when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5,500 ft. per minute. On a compressor running at a piston speed of 550 ft. per minute, this requires a valve area equal to 10 per cent. of the piston area. The practice of making suction valve areas larger than those of the discharge valves is not advised, as, while the incoming air is of greater volume, the discharge valves remain open for a very small proportion of the stroke.

It is claimed that when drilling in sandstone the drill-bit should be tapered somewhat and then flattened instead of drawn to a cutting edge. If a chisel-bit is used in drilling sandstone, the bit will wear very sharp, and will frequently become fitchered.

Rock drill pipe lines, says the *Mining Reporter*, which have become choked by freezing may be cleared by turning a very small amount of wood alcohol into the line. This will not prevent freezing for any length of time, but will be of the greatest aid in loosening frost already formed.

An interesting example of the use of magnetism in an emergency occurred recently in Philadelphia. At the Mint a well has been bored which has reached a depth of some 54 feet. A few weeks ago one side of the jar rein of the drill, 18 inches long and weighing 110 pounds, broke off and wedged crossways in the hole at the bottom. The contractor doing the work fished ten days trying to recover the broken piece without result. The problem was solved by the construction of an improvised electro-magnet consisting of a piece of steel 33 inches in diameter, on one side of which was wound a coil protected by a copper sheathing. Long leads were attached and the apparatus was lowered down the boring. The current. 1¾ amperes, at 220 volts, was then turned on, and the magnet was pulled up, bringing with it the broken tool and all the metal particles that were in the well from the boring.

Where compressed air is available, the small air-hammer drill may prove to be an excellent tool for use in sampling a hard vein. The machine should be provided with a moil-shaped bit, instead of with the ordinary blunt-chisel bit usually employed in drilling. The success of the use of this device depends largely upon the practical sense of the man manipulating the machine. The air-hammer drill has proved its usefulness in rapidly drilling shallow holes, and there seems no good reason why in competent hands it should not be useful in cutting a channel of uniform depth and width across a vein of hard rock of any description.—*Mining and Scientific Press.*

ABOUT FORGING BITS.

In forging rock drill bits those for medium hard rock should have sharp chiseled bits. As the hardness of the rock increases, the angle of the bit may be made more blunt and the cutting edge shaped from a straight line to a curve, so as to prevent the corners from being chipped off. There are economies in the foregoing bits to the best advantage with reference to the stone that is being worked especially, which would constitute quite a factor in the whole cost of the quarrying operation, for it costs just as much to work with a bit that is doing very little actual cutting as it does to operate where every blow is cleaving straight into the stone.

The cost for motive power, whether it is for steam or compressed air and the wages of the man working the drill goes on just the same, whether he is idly pounding or whether his tool is cutting properly. A little experimentation on the part of the man who forges the tools is in order in many quarries where the thing is being done in a slipshod manner. It is very easy to find out just what kind of a bit yields the best result, and this should be the pattern for all other bits working in the same kind of strata. Of course in most large quarries, the rock varies considerably, and it is well for the man who operates the drill to change his bit to suit the specific kind of a cut that he is making. The man who forges the bits should have every kind that will be called for, provided to be furnished on a moment's notice.

According to the *Engineering Record*, compressed air locomotives are used in handling the 11,700 tons of ore, limestone, coke and coal brought daily to the Washoe plant of the Anaconda Copper Mining Co. Counting rehandled materials twice, more than 13,000 tons are handled about the works by means of thirteen compressed-air locomotives, twelve weighing 13 tons each, and one, 21 tons. Each locomotive carries two storage-tanks for its air-supply, the air being taken from a pressure-system of pipes laid conveniently to the tracks, and having stations at which the locomotive stops to get its air-supply. This supply is carried at from 800 to 900 lbs. per square inch. A reducing-valve between the storage-tanks and the cylinder reduces the pressure to 150 lbs. A fresh supply of air is taken at times ranging from twenty to sixty minutes. For this particular service, where the distances run are short, and where the cars are frequently stopped and started, the compressed-air locomotives have been most satisfactory, for convenience, reliability and simplicity of operation. They have been in constant service since 1900, and have needed only the natural running-repairs. They are operated over tracks aggregating 48 miles in length, which are distributed over the side-hill location of the works about half a mile square. The present locomotives have been able to stand the hardest and roughest usage with but little injury. Under like conditions, it is believed that electric locomotives would have had coils burned out, short-circuiting and other troubles.

THE weakest point in electrical transmission, is the absence of proper means for storing electrical energy on a large scale at a reasonable cost. This requires that the whole plant be capable of supplying current at the greatest rate still likely to be called for at any moment, and still provide an ample reserve of capacity in case of a break down in any part of the system. In this connection, the advocates of gas claim that this latter power can be readily and cheaply stored in quantity, for any desired length of time, and used at whatever moment and in any amount without deterioration or loss. The plant, if necessary, may be shut down for a time without interrupting the supply. Until recently, however, it has not been considered possible to convey gas with any success over long distances. This has been due to a lack of efficient compressors, and of pipes and joints not capable of withstanding, without excessive leakage, the pressures which would have had to be employed. With air compressors having a total efficiency as high as 77 per cent., and steel pipes capable of carrying high pressures and obtainable in longer lengths, thus reducing the number of joints, gas is becoming a power which in many cases compares favorably with electricity.—*Engineering and Mining Journal.*

PROPORTIONING CONCRETE

In a paper by Sanford E. Thompson, read before the Boston Society of Civil Engineers, the author, after discussing various methods and tests, offers the following suggestions as guides to proportioning concrete:

1. The size of the largest stone in the aggregate should be as great as is consistent with proper placing of the concrete.
2. If size of stone is small, a richer mixture must be used: thus 1:3:6 is a fairly rich mix with 2-inch stone, but a lean mix with ½-inch stone.
3. If sand is fine, a smaller quantity may be used in proportion to the stone.
4. For concrete a sand with too large a percentage of very coarse grains may be detrimental because they will not fit into the voids of the coarse aggregate.
5. If the broken stone or gravel contains fine stuff, a smaller proportion of sand must be used.
6. Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions, than by using the run of the bank or the run of the crusher.
7. If the mortar in concrete is rich, say, up to 1:2½, sand should be coarse, with comparatively few fine grains. A lean mortar, on the other hand, is improved not only in strength but in smoothness of working, by using a sand containing dirt or dust.
8. If fine sand must be used, the proportions must be richer than for coarse sand, because a fine sand makes a mortar of lower density.

MACHINE AND HAND DRILLING.

The rate at which a tunnel can be driven by means of rock-drills may be safely taken at double the speed of hand-work. Thus, in driving the Vosburg tunnel (8 by 20 ft.) on the Lehigh Valley Railroad, through a uniform hard gray sandstone, by hand drilling, the progress was 67 ft., while by machine-drilling it was 173 ft. monthly. For driving or for sinking, rock-drills are far superior to hand-labor, both in speed and in economy. For stopping, however, except in wide stopes, the differences are not so marked, as it is difficult to maneuver a machine in places where a man can hardly find room to work with a single-hand hammer. The great advantage in the use of rock-drills is undoubtedly the increased speed with which a mine can be developed and ore reserves created, since, for cost per yard, there is not much difference between either that or hand-drilling. The point is a little difficult to decide, but it would be safe to say that the average cost per yard by either system is the same for ordinary mine drifts, while, for full-sized tunnels, machine-drilling is cheaper.—*Mining and Scientific Press.*

AT several mines in Europe small compressors, electrically driven, have been installed underground, each compressor serving a group of drills. The compressor motor and receiver are sometimes arranged on a truck, which can be moved to follow the development of the mine. The electrical cable is wound on a drum, enabling the easy adjustment of the length.

The efficiency of these installations has been found very good. By this method the theoretical advantage of the electric drill is approached, while the practical advantage of the air drill is retained.—*Engineering and Mining Journal.*

Where compressed air is used, the initial energy may be restored by adding a slight amount of heat to the air at the point of application; in fact, the employment of a re-heater increases the volume to such an extent that additional energy is gotten when air is used expansively at a rate of 1 H. P. per lb. of coal. In mine operations the re-heater is never pushed to its limit, so that it will not interfere with the comfort and health of the men. Compressed air is only raised in temperature slightly to make up for the transmission drop in pressure.

IN compressed-air haulage no serious difficulty from freezing in the exhaust passages of the locomotive will be encountered if high pressures are used. Only in case of low pressure will freezing occur. Where higher pressure is used, practically all of the moisture is squeezed out of the air in the process of compression and deposited in the stationary storage, or in the tanks on the locomotive, whence it can be drawn off at intervals. The only other cause of freezing may be the use of a poor quality of oil.

U. S. PATENTS

ESPECIALLY PREPARED FOR

COMPRESSED AIR

835,936. PNEUMATIC HAMMER. Charles T. Carnahan and Jeremiah Murphy, Denver, Colo.; said Murphy assignor to said Carnahan. Filed June 28, 1906. Serial No. 323,944.

Claim.—A pneumatic hammer comprising a throttle-valve mechanism positioned at right angles with respect to the cylinder of the hammer, said mechanism having as a part thereof, an air-inlet nipple extending at right angles with respect thereto.

836,101. APPARATUS FOR CIRCULATING LIQUIDS IN DYE-VATS. Louis Dumons, Roubaix, France. Filed June 12, 1903. Serial No. 161,156.

836,105. LOAD-BRAKE APPARATUS. Clyde C. Farmer, Chicago, Ill., assignor to Westinghouse Air Brake Company, Wilmerding, Pa., a Corporation of Pennsylvania. Filed Feb. 17, 1904. Serial No. 194,109.

836,124. LOAD-BRAKE APPARATUS. Harry R. Mason and Clyde C. Farmer, Chicago, Ill., assignors to Westinghouse Air Brake Company, Wilmerding, Pa., a Corporation of Pennsylvania. Filed Feb. 17, 1904. Serial No. 194,101.

836,160. FLUID-PRESSURE BRAKE. Henry H. Westinghouse, Pittsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Feb. 19, 1904. Serial No. 194,348.

836,215. TUNNEL CONSTRUCTION AND METHOD AND APPARATUS FOR FORMING THE SAME. Jesse W. Reno, New York, N. Y. Filed March 5, 1906. Serial No. 304,310.

836,258. REDUCING-VALVE. Josef Hubner and Isidor Mayer, Vienna, Austria-Hungary. Filed Feb. 19, 1906. Serial No. 310,918.

836,268. AIR-CUSHION FOR PRINTING-PRESSES. Robert Miehle, Chicago, Ill. Filed Dec. 19, 1902. Renewed Sept. 26, 1904. Serial No. 225,975.

836,306. REDUCING-VALVE. Harry F. Cunning, Roanoke, Va. Filed June 19, 1906. Serial No. 322,454.

836,320. PNEUMATIC BOBBIN-CONVEYER FOR MILLS. Patrick J. Hanlon, Leicester, Mass. Filed May 2, 1906. Serial No. 314,771.

836,344. AIR-BRAKE COUPLING. Carl Schumacher, Newport, Ky. Filed June 11, 1906. Serial No. 321,215.

836,524. PNEUMATIC LIFE-SAVING SUIT. Edward Morrell, San Quentin, Cal. Filed June 14, 1904. Serial No. 212,577.

836,532. PNEUMATIC GUN OR RIFLE. James Picken, Port William, Scotland, assignor of one-half to Arthur Allan, Jr., Glasgow, Scotland. Filed Dec. 30, 1902. Serial No. 137,115.

836,624. AIR COMPRESSING AND COOLING APPARATUS. Rudolf Berg, Pittsburg, Pa., assignor of one-half to Ferdinand Wenig, Pittsburg, Pa. Filed April 22, 1905. Serial No. 256,836.

Claim.—In an air compressing and cooling apparatus, the combination of two casings of cross shape arranged sidewise of each other, a horizontal cylinder supported at the meeting joint of said casings, said cylinder being open at both ends, a piston reciprocating in said cylinder, spiral isothermal coils supported in the lower parts of the extension-cylinders, of the casings, discharge-valve chambers supported on said extension-cylinders and axially in line therewith, suction-tubes extending through the extension-cylinders and discharge-valve chambers, fillet-rings located on said suction-tubes in the discharge-valve chambers, suction-vales located on the lower parts of the suction-tubes, discharge-valves guided on said fillet-rings, perforated valve-seats for the suction and discharge valves, the suction-valve seats being located at the lower ends of the suction-tubes and the discharge-valve seats in the bottom part of the discharge-chambers.

836,630. PUNCH OR RIVETER. Samuel S. Caskey, Philadelphia, Pa. Filed Feb. 7, 1903. Serial No. 142,330.

Claim.—In a riveter or punch, a stationary non-compressible reservoir adapted to normally contain oil or other liquid and communicating directly with the riveting-chamber, and having an outlet in proximity to the central portion of said reservoir, said outlet being normally always beneath the surface of said liquid, and means for admitting a slight leakage of compressed air upon the surface of said liquid.

836,682. AIR-BRAKE SYSTEM. George R. Henderson and Walter V. Turner, Topeka, Kans., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Nov. 13, 1902. Serial No. 131,240½.

836,705. AIR-BRAKE SIGNAL SYSTEM. Thomas J. Quirk, Buffalo, N. Y. Filed June 20, 1906. Serial No. 322,587.

836,716. PNEUMATIC WHEEL. George H. Treadgold, Port Huron, Mich. Filed Dec. 16, 1905. Serial No. 292,061.

836,720. REGULATOR-VALVE FOR AIR-BRAKE SYSTEMS. Walter V. Turner, Topeka, Kans., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Jan. 2, 1903. Serial No. 137,554.

836,772. PROCESS OF MANUFACTURING PNEUMATIC TIRES. Arthur H. Marks, Akron, Ohio. Filed Jan. 13, 1906. Serial No. 295,952.

836,778. PNEUMATIC HAMMER. Allen J. Patch, Beloit, Wis., assignor to Fairbanks, Morse & Company, Chicago, Ill., a Corporation of Illinois. Filed July 6, 1904. Serial No. 215,555.

Claim.—In a pneumatic hammer a cylindrical shell valve provided with three seating surfaces and an inclined surface, in combination with a valve seat having an annular passage adapted to be closed by said valve in one position and opened by the shifting of said inclined surface, substantially as described.

836,824. ROCK-DRILL BIT. John B. Pace, New York, N. Y. Filed Nov. 21, 1905. Serial No. 288,347.

836,846. ROCK-DRILL. William C. Whitcomb, Chicago, Ill. Filed Nov. 2, 1905. Serial No. 285,617.

836,883. BURNER. Benjamin F. Jackson, Boston, Mass., assignor to Boston Crude Oil Burner Co., Boston, Mass., a Corporation of Maine. Filed July 8, 1904. Serial No. 215,709.

836,886. QUICK-RECHARGING TRIPLE VALVE. William B. Mann, Baltimore, Md., assignor to American Air-Brake Company, a Corporation of New Jersey. Filed July 1, 1903. Serial No. 163,949.

836,973. SYSTEM OF MOTOR CONTROL. George H. Hill, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed May 20, 1905. Serial No. 261,293.

836,981. TRAIN-CONTROL SYSTEM. Charles E. Lord, Cincinnati, Ohio, assignor to General Electric Company, a Corporation of New York Filed Oct. 1, 1904. Serial No. 226,749.

837,037. MOTOR-CONTROL APPARATUS. Frank E. Case, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed April 17, 1905. Serial No. 255,868.

837,086. PNEUMATIC CUSHION FOR VEHICLES. Andrew M. Lockett, New Orleans, La. Filed April 28, 1906. Serial No. 314,162.

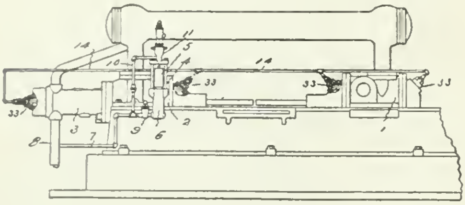
837,098. HOSE-COUPLING FOR RAILROAD-TRAINS. Alexander T. Morton, Pittsburg, Pa. Filed Sept. 29, 1906. Serial No. 336,785.

837,118. ROCK-DRILL. Joseph J. Rekar, San Francisco Cal. Filed April 13, 1906. Serial No. 311,461.

837,207. MASSAGE-PUMP. Henry P. Engeln, Cleveland, Ohio, assignor to The H. P. Engeln Company, Cleveland, Ohio, a Corporation of Ohio. Filed Sept. 29, 1901. Serial No. 226,482.

837,327. MECHANISM FOR UNLOADING AIR COMPRESSORS. Henry P. Morgan, Norwalk, Conn., assignor to The Norwalk [illegible] Company, South Norwalk, Conn., a Corporation of Connecticut. Filed Aug. 12, 1905. Serial No. 273,905.

Claim.—1. In an apparatus for relieving the pistons of a multiple-stage compressor, the combination with an inlet-valve of each cylinder, of a plunger located adjacent to and adapted to be actuated by air-pressure for rendering inactive each inlet-valve, a connection for air extending between the discharge of the high-pressure cylinder and each plunger-chamber, a valve normally closing the air-passage through said connection, a piston adapted to open this valve, a connection for air for actuating said piston, and a valve set to open at the desired pressure in the connection to the piston-cylinder, substantially as specified.



837,347. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Co., Ottumwa, Iowa. Filed July 5, 1906. Serial No. 324,804.

Claim.—1. In a rock-drill, the combination with the hammer-barrel and the hammer, said barrel having an inlet and an exhaust chamber, of a drill having an longitudinal passage therethrough and held in one end of said hammer-barrel, said barrel having a water-chamber, means for admitting water into said water-chamber to pass through said drill, said hammer-barrel having a valved passage between the exhaust and the water chambers, and means for controlling the water admission to the water-chamber, substantially as shown and described.

837,358. LOCAL-APPLICATION AND EQUALIZING VALVE. Walter V. Turner and David M. Lewis, Raton, N. Mex., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 4, 1902. Renewed March 24, 1905. Serial No. 251,847.

837,369. ELECTRO-PNEUMATIC BRAKE. Edward Wright, Edgewood Park, and Walter V. Turner, Wilkinsburg, Pa., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed March 20, 1905. Serial No. 250,988.

837,416. AIR-BRAKE. Hugh M. Marsh, Chicago, Ill. Filed July 16, 1906. Serial No. 326,402.

837,458. PNEUMATIC. TIRE Harry C. Fairchild, Passaic, N. J. Filed March 30, 1905. Serial No. 252,862.

837,772. SAFETY-VALVE FOR PNEUMATIC TIRES, William S. Arnold, San Francisco, Cal. Filed June 2, 1906. Serial No. 319,949.

837,856. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill., assignor of one-half to William M. Bayne, Chicago, Ill. Filed Aug. 27, 1906. Serial No. 332,124.

Claim.—1. In a pneumatic tool, the combination of a casing carrying at one end the tool, a reciprocating piston in the casing, air-chambers in the opposite ends of said casing, between which the piston works, one of said chambers having a supplemental inlet-port communicating with

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837,990. VALVE-GEAR FOR PNEUMATIC ROCK-DRILLS. Carl Weidman, Würselen, Germany, assignor of one-half to Paul Hoffman, Eiserfeld, near Siegen, Westphalia, Germany. Filed June 17, 1905. Serial No. 265,649.

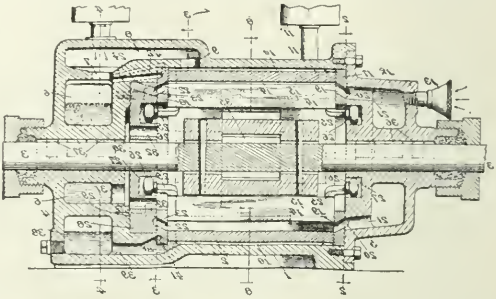
838,103. CAR AND AIR-BRAKE HOSE-COUPLING. William W. Gordon, Washington, D. C. Filed Aug. 15, 1906. Serial No. 330,724.

838,106. PNEUMATIC CUSHION FOR VEHICLE-SPRINGS. Caleb. S. Gurney, Portsmouth, N. H. Filed Dec. 18, 1905. Serial No. 292,315.

838,138. AUTOMATIC APPARATUS FOR PREVENTING COLLISION OF RAILWAY TRAINS. Maurice Privat, Angoulême, France. Filed Jan. 23, 1904. Serial No. 190,368.

838,140. AIR-COMPRESSOR. Lebbeus H. Rogers, New York, N. Y. Filed Feb. 2, 1905. Serial No. 243,868.

Claim.—1. In a compressor, a cylinder, a drum revolving in said cylinder, a piston in said drum, an oil-chamber, a conduit leading therefrom to the rear of said piston, and means operated by the drum for delivering oil from said cylinder to said oil-chamber.



838,141. SIGNAL APPARATUS. Hermann Sandvoss, Neuss, Germany. Filed April 5, 1906. Serial No. 309,983.

838,308. STOP-COCK FOR AIR-BRAKE SYSTEMS. Samuel H. Dunning, Paterson, N. J. Filed April 7, 1906. Serial No. 310,514.

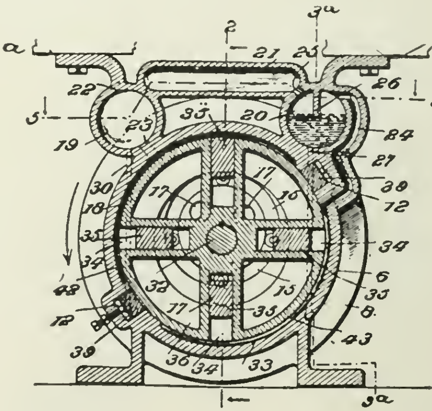
838,336. AIR-LOCK. Henry Japp, New York, N. Y., assignor to S. Pearson & Son, Inc., Long Island City, N. Y., a Corporation of New York. Filed April 20, 1906. Serial No. 312,936.

838,337. VALVE FOR AIR-LOCKS AND THE LIKE. Henry Japp, New York, N. Y., assignor to S. Pearson & Son, Inc., Long Island City, N. Y., a Corporation of New York. Filed Sept. 10, 1906. Serial No. 334,009.

838,363. POWER-HAMMER. Harry B. Stocks, Manchester, England, assignor to The Climax Patents Limited, Manchester, England. Filed Aug. 31, 1905. Serial No. 276,600.

838,42. COMPRESSED-AIR RAILWAY-TRAIN BRAKE. Adolph A. Osoling, St. Petersburg, Russia, assignor to Oscar Mietens, St. Petersburg, Russia. Filed May 31, 1906. Serial No. 319,601.

838,458. ROTARY COMPRESSOR OR PUMP. Lebbeus H. Rogers, New York, N. Y. Filed Sept. 9, 1904. Serial No. 223,913.



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ENGINEERING

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